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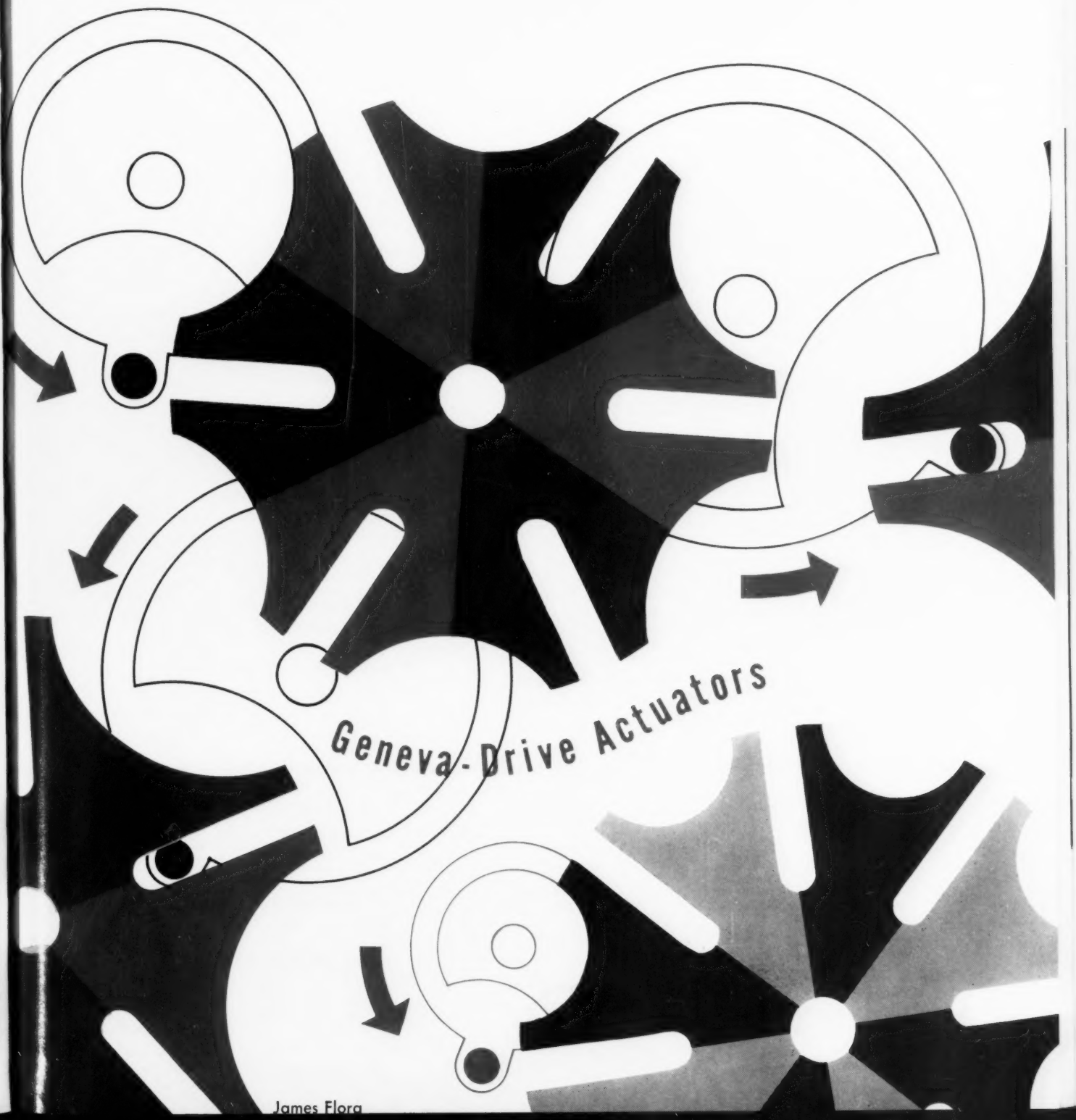
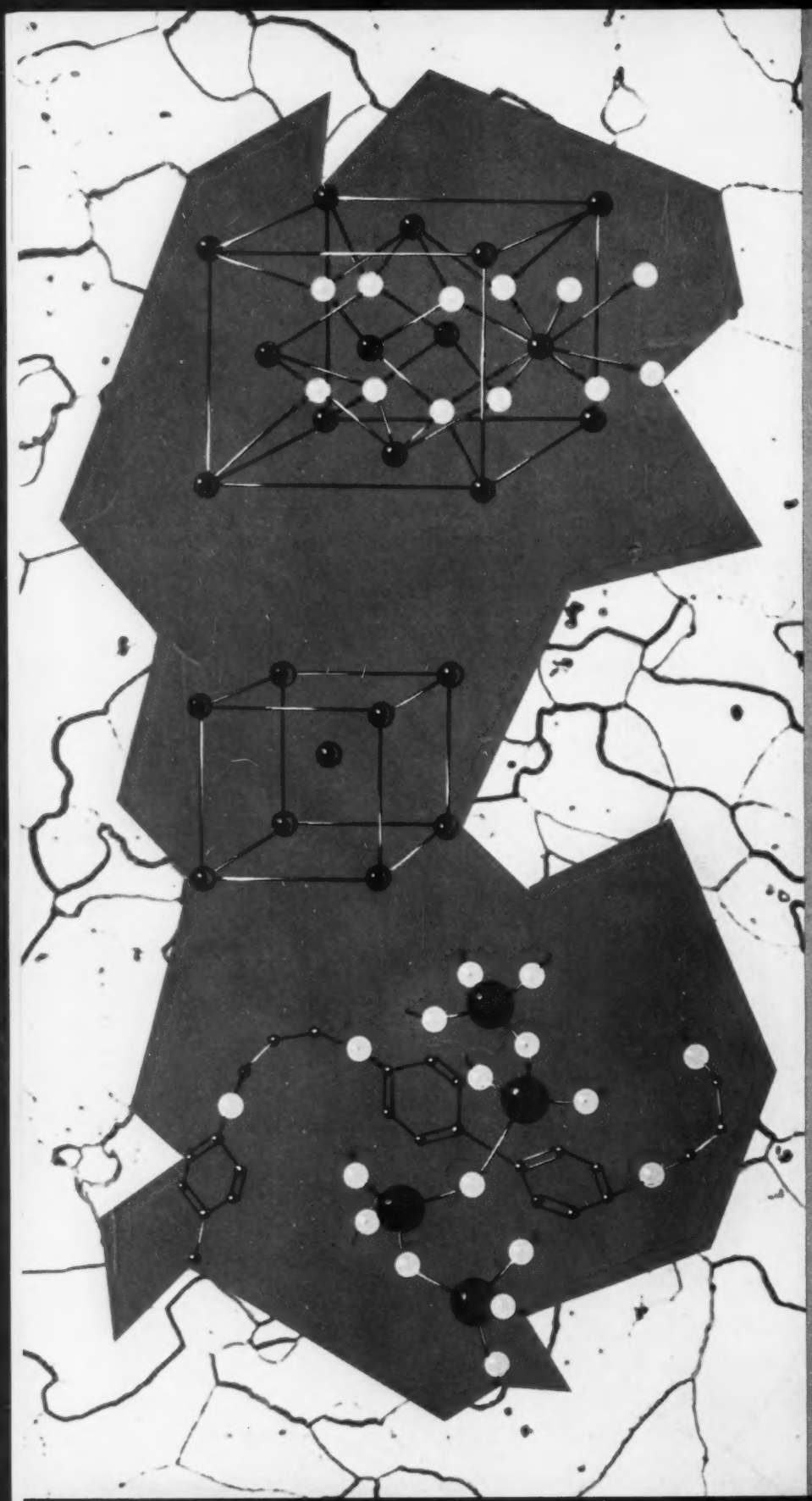
ELECTROMECHANICAL
components & systems DESIGN

NOVEMBER 1958



Geneva-Drive Actuators

James Flora



NEW APPROACH TO "OLD" MATERIALS

By today's standards, the "old" refractory metals are outdated. The ultimate in high-temperature studies of 10 years ago is several generations behind in terms of modern aircraft and missile development.

Today's material requirements surpass anything envisioned 10 short years ago. Molybdenum and beryllium, for example, are still exciting metals with much promise for space vehicles and ultra-high-speed aircraft. It now appears, however, that the full promise of such metals may be fulfilled when they are used, not alone, nor as alloys, but when combined with other materials to form totally new types of structural materials.

Such a "marriage" of metals, ceramics and plastics is a promising approach to high-temperature problems that is being vigorously pursued at Avco. It opens new potential applications for many exotic combinations.

These bold steps forward are possible at Avco, where materials research includes concurrent basic studies and applied research, plus developmental programs that extend through the solution of processing and testing problems.

The search for new knowledge goes forward simultaneously with the creation of advanced technology at Avco's Research and Advanced Development Division. The creative man, whether he is interested in basic studies or practical problems, finds his effort enhanced by the stimulus of interdisciplinary contact and feedback from other related fields.

Research and Advanced Development is more than a descriptive title at Avco. It is a concept that promotes creativity.

Avco

Research and Advanced Development division

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NOVE

NOVEMBER 1958
VOLUME 2—NUMBER 9

ELECTROMECHANICAL components & systems DESIGN

The Sourcebook of Design Ideas and Techniques in Applied Eltromechanics

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What is an ELECTROMECHANICAL ENGINEER?

HE'S THE NEW DESIGNER

For years industry teamed the electronic engineer with the mechanical engineer so that they could design together what each could not develop alone. This merger—still current practice—has brought forth a new breed of engineer: the designer who combines the ideas and techniques from both fields into new and improved products for industry, the military and the consumer.

He's the engineer with one foot planted firmly in electronics theory and practice and the other in mechanical theory and practice. He selects and specifies electronic and mechanical components, materials and sub-systems for application in today's and tomorrow's market—the *electromechanical* Original Equipment Market.* Proof? Just look at any of the machinery, equipment, appliance and military systems now rolling off our production lines.

WHO SAYS SO?

Paragraph 1 — Chapter 1 from a new book ENGINEERING SYSTEMS ANALYSIS
by Robert L. Sutherland, State University of Iowa

"One of the helpful avenues of approach to a more complete understanding of the broad problems facing the engineer today is the study of the analogies existing in engineering. This is particularly true for the electromechanical engineer (and many graduates have discovered that their work actually falls into this classification), whose technical understanding requires that one foot must be planted in the theory of electrical engineering and the other in that of mechanical engineering."

(Addison-Wesley Publishing Co., Inc. Reading, Mass.)

HE READS

ELECTROMECHANICAL
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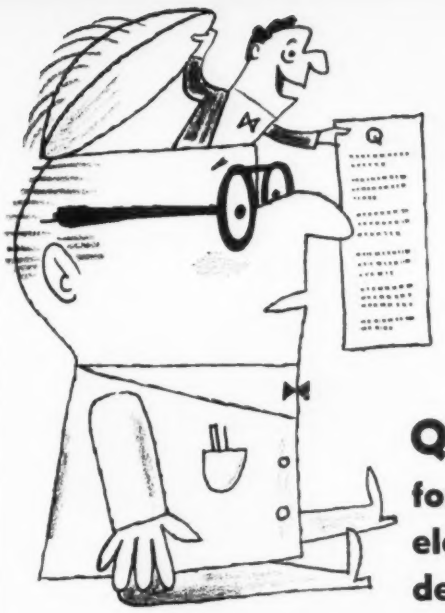

QUESTIONS
for an electromechanical design engineer

1 What are the highest accuracies now available in single or multi-turn potentiometers? What increase can you expect in the near future?

2 *Pot manufacturers have announced accuracies of 0.01 and 0.005 percent in special types. To what extent can these accuracies be maintained in practical military and commercial applications?*

3 What are the maximum temperatures to which you can expose various types of precision pots? What is the life of these units and their degradation at these temperatures assuming negligible dissipation? What is their independent linearity?

4 *What factors affect the performance of precision wire wound pots with use? What special types are particularly resistant to destructive forces in the environments to which they may be subjected?*

5 What are the prevalent commercial and military standards for precision pots?

6 *What is the "effective" resolution of precision carbon pots? of metal film pots? How "infinite" is the "infinite" resolution of these types of pots? How do their resolutions and independent linearity compare with conventional wire wound pots?*

7 What precautions must the application engineer heed when selecting given types of pots for specific applications?

8 *What is the smallest of each type of pot commercially available and what are the practical limits of their performance characteristics?*

9 What's the next biggest improvement in resistance pots, particularly with respect to performance characteristic?

10 *What are some types of unusual pots for special applications?*

ANSWERS

Don't miss the December issue of Electromechanical Design. It will feature Components Design #2 and will be devoted to a definitive roundup of potentiometer information. You'll find answers to all of the above questions plus the hundreds of others that confront you daily.

It's an issue you'll want for your files.

DEC. 1958

ELECTROMECHANICAL
components & systems | **DESIGN**

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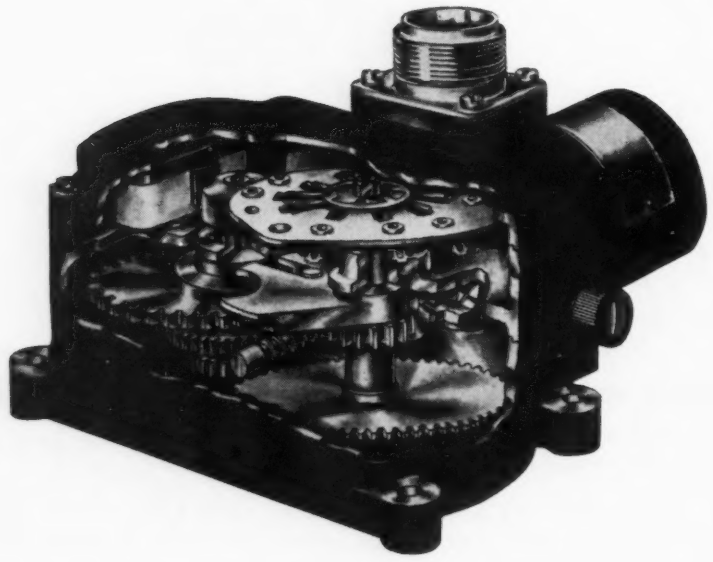


Cutaway drawing of 2 position 90° Geneva-Loc actuator shows the Geneva cam and sector; driving pin; worm and driving gears; snap and wafer switches.

Geneva-Drive Actuators

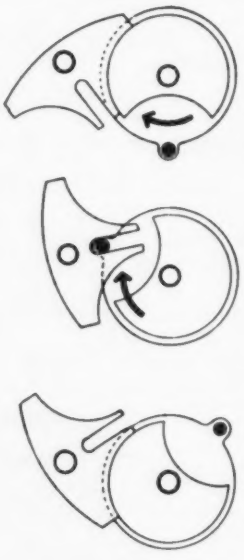
Positive Mechanical Positioning of Electrically Driven Actuators

Mention the term *Geneva* drive to the average engineer and chances are he will think of applications in terms of clock escapements or indexing systems on machine tools and packaging machinery. Now there is another area of application that he can think of: electrically powered and mechanically positioned actuators that possess no moving clutches, brakes, or limit switch adjustments.

The adaptation of Geneva drive principles to electric actuators is actually not a new one. Mr. R. C. Hoof, manager of Bendix Aviation's Electromechanical Section in North Hollywood, California assures us that this particular application was patented ten years ago and has been in production ever since; on the other hand we have found few engineers that know of this particular application. And nothing has appeared in print during the past ten years on the subject. So here it is.

The story starts back in 1944 when Bendix Aviation was approached with a problem: two-speed blower shift levers on the engines of a C-47 Skytrain were slipping into neutral causing the engine to burn out in a very short time. Any leakage in the hydraulic system that controlled the lever caused this serious problem. The Army wanted a non-hydraulic actuator that would mount directly on the engine where severe vibration existed. In addition, to accurately position the shift lever within close tolerances, the actuator had to lock the lever into each position so that subsequent failures or environmental conditions would not cause the lever to unlock.

FIG 1—BASIC GENEVA CAM OPERATION



(1) The driving pin is about to enter the Geneva sector. Output torque available at this point is theoretically infinite and the sector speed is zero. As the pin enters the slot the sector begins to rotate.

(2) When the driving pin reaches the common center line between the driving and driven shafts the output shaft attains its maximum speed and the available torque is at a minimum.

(3) During the last half of the cycle the sector speed is gradually reduced. As the pin leaves the slot the output shaft speed is again zero and the locking cam is engaged to hold the shaft securely in position.

DESIGN BACKGROUND

Mr. Hoof recalled that Bendix considered first the use of a conventional actuator developed during the war to operate dive flaps on the P-38 airplane. Output lever positioning with this type of actuator depends upon accurate human adjustment of precision limit switches. After a drive motor is started, a clutch mechanism engages and a gear train drives the output shaft at a continuous speed until a cam actuates a limit switch interrupting current to the motor. A solenoid simultaneously releases the clutch disc that transmits power from the armature to the gear train. This disc moves automatically under spring pressure to a brake surface which brakes the gear train and dissipates any kinetic energy remaining in the gear train. Disadvantages of these conventional actuators are:

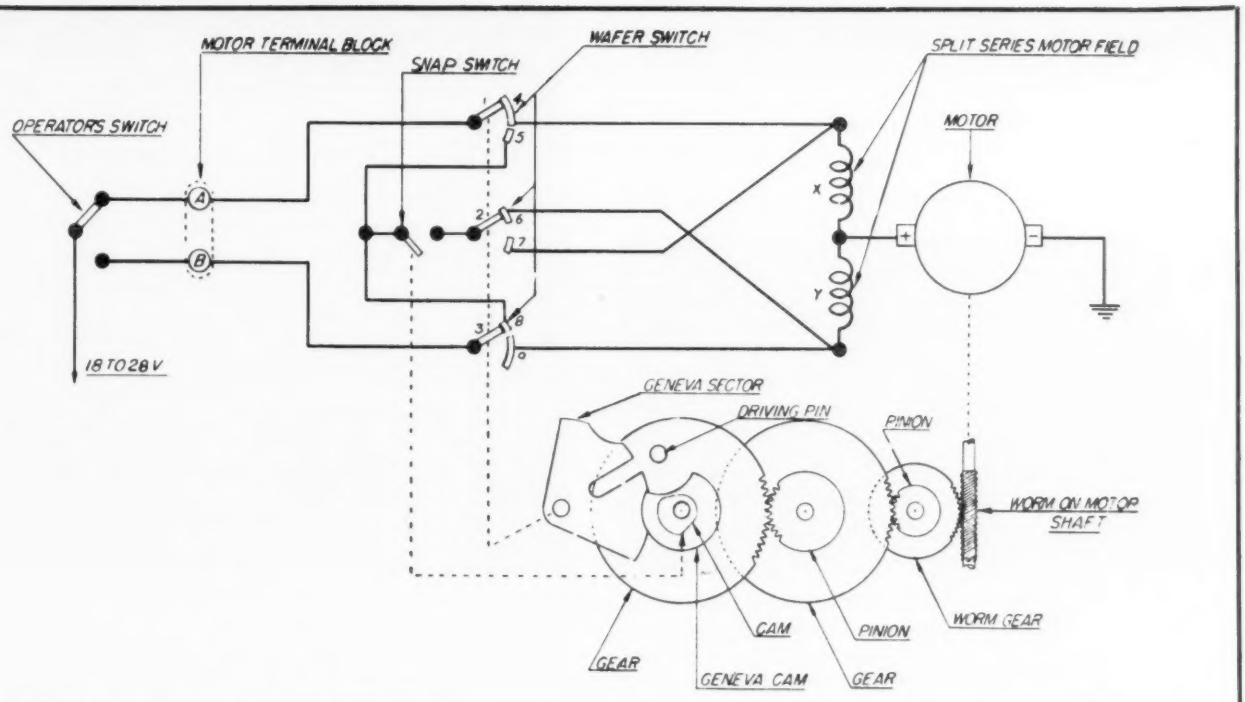


Fig 2—Use of a wafer switch greatly reduces the number of switches required for motor field switching and a snap switch removes the necessity of the wafer switch breaking motor current. Closing the operator's switch supplies power to the motor thru wiper 1 and contact 4 of the wafer switch, starting the actuator in the forward direction. The motor starts under no load and the driving pin approaches the Geneva sector slot. Just before this pin enters the slot, the cam closes the snap switch. As the rotor of the wafer switch turns with the ouput shaft, the three wiper contacts begin to move. When wiper 1 reaches a certain point it touches both contacts 4 and 5 temporarily.

Since the snap switch is now closed, a parallel current path exists through the snap switch, wiper 2, and contact 7 of the wafer switch to the field. As the wafer switch rotor continues to turn, rotor 1 leaves contact 4 but the circuit is complete through contact 5 and the snap switch. No arcing occurs because the contacts break no current. After the output shaft has completed its travel and is locked in position, the cam on the driving wheel again operates the snap switch, breaking the circuit to the motor and the motor coasts to a stop without any further movement of the output shaft. Operation in the reverse direction occurs through the same series of effects but in the opposite direction. Note that the driving pin is free of the Geneva sector before the motor circuit is interrupted and the snap switch always breaks no-load current.

- Accurate stopping requires perfect operation of limit switches, clutches, and brakes; and settings are subject to misalignment by vibration. Human error enters into the setting of the limit switches.
- Clutch slippage and wear occur because the motor starts before the drive plate engages.
- The brake surface must absorb whatever energy is present in the gear train and is consequently vulnerable to vibration and susceptible to wear.
- These last two conditions present undesirable shock loads to the gear train and motor.

GENEVA STOP MECHANISM

To solve these problems, Mr. Hoof said, Bendix engineers investigated the possibility of using a version of a stop device known as the Geneva stop mechanism invented in the early 14th century by Swiss watchmakers to prevent overwinding of delicate watches. The stop mechanism with an interrupted driven wheel allows only a predetermined number of revolutions of a driving shaft. Since this mechanism produces an intermittent speed on the stop cam or driven member, Bendix engineers used it as the basis for an actuator mechanism. Figure 1 explains its operation.

DESIGN APPROACH

In Bendix's patented Geneva-Loc design, the shape of the Geneva cam and sector accurately controls the travel of the output shaft and provides a positive lock at each position. Vibration cannot move the output shaft. Output shaft travel is now a mechanical function rather than an electrical function and no longer depends upon accurate adjustment of limit switches. This accurate positioning without the use of clutches and brakes removes the human element associated with adjusting switches, clutches and brake plates. Figure 2 explains and illustrates the operation of the gearing and switching mechanism incorporated in the final stage of the gear train.

The gear ratio through the mechanism varies as the output shaft rotates such that maximum torque is available at the breakaway position (Figure 4). Output shaft acceleration and deceleration is a smooth curve, eliminating shock loads on the gear train and motor. Velocity of the output shaft starts at zero, increases to the point of maximum acceleration where the driving pin has rotated approximately 165° from its starting position, and reaches its maximum value at its center of travel which is the point of minimum available torque (Figure 3).

This movement has been used in a number of machines, Mr. Hoof explained, including motion picture projectors where smooth intermittent operation is required; motion takes place in only a fraction of a second without shock loads that could tear the film perforations.

Upon reflection, Mr. Hoof recalled, "As a result of my engineering contact with the various airframe and missile people, I find that the greatest interest, aside from the Geneva drive itself, is in the switching circuits available."

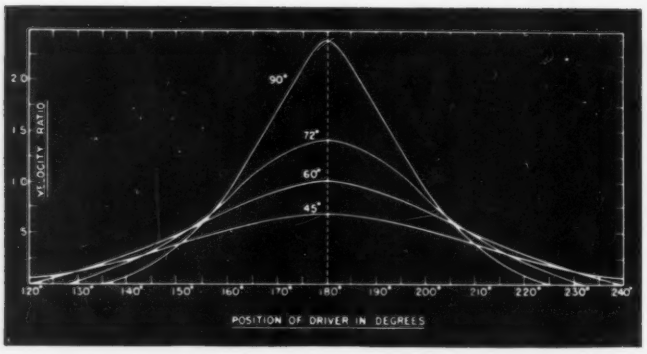


Fig 3—Composite actuator output-shaft velocity curves show that velocity starts at zero, builds up gradually with its maximum acceleration occurring somewhere around the 165° driver rotation points, and reaches its maximum value at the center of travel.

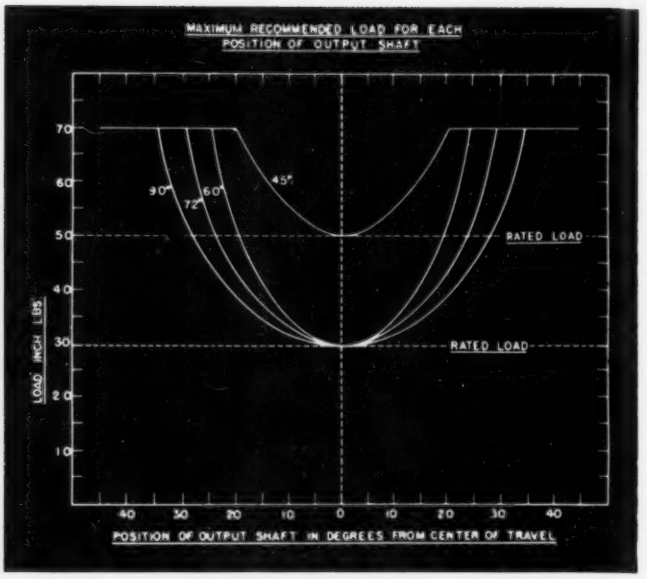


Fig 4—Composite torque curves for the 45°, 60°, 72°, and 90° actuators show that maximum torque is available at the start and finish of each cycle and minimum torque is available when the output shaft goes through the center of travel. This characteristic allows use of smaller than normal actuators for savings in weight and space.

Built-in switches in the actuator function such that the motor will continue until the driving pin has left the Geneva sector and the output shaft is mechanically locked in position (Figure 2). This is accomplished by the use of a master snap switch actuated by a cam which is concentric with the Geneva cam, and a wafer switch which is controlled by the Geneva sector. These switches are wired such that at no time does the wafer switch break load motor current.

Great electrical simplification results from the use of the snap and wafer switches. For example: a conventional eight-position 45° reversible actuator requires 16 limit switches and as many adjustments; the applicable Geneva-Loc actuator uses only one snap switch and single double-deck wafer switch with the latter neither making or breaking any circuits. All switches can be mounted securely in place without provision for adjustment since shaft positioning is not accomplished by limit switches. Once installed the actuator requires no attention.

In summary, Mr. Hoof said that the advantages of the Geneva drive actuators are:

- No limit switch adjustments, clutches or brakes are required. For the first time the human element does not affect the operation of an electric actuator.
- Positioning is purely mechanical with positive mechanical locking a bonus characteristic.
- Drive motor comes up to speed under no load and the varying drive ratio causes power to be applied in a manner best suited for accelerating and decelerating the driven load.
- Cut-out switches always operate after output shaft is locked in position and switches operate at no load motor current resulting in maximum switch life.
- The entire assembly may be readily removed and replaced because it is not necessary to set limit switches

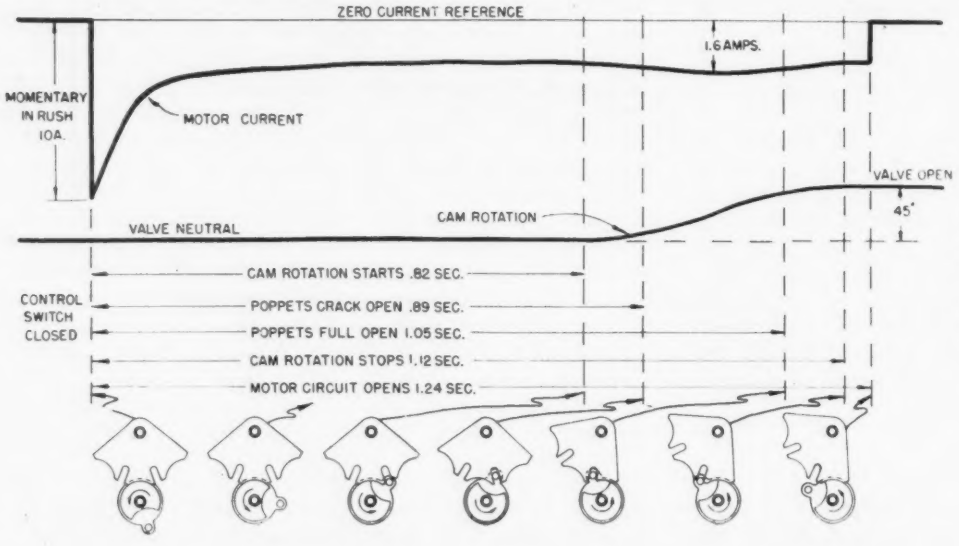


Fig 5—Motor current, cam rotation, and Geneva sector position of a 3 position 45° unit are shown related in time as the output sector completes one cycle by rotation through 45°.

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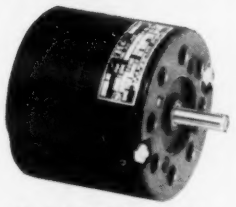

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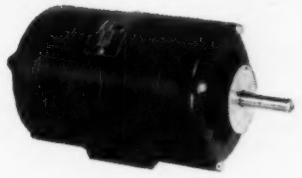

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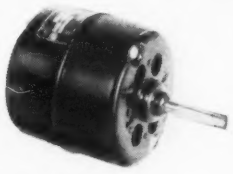

Model 11A Illustrated
Universal and D.C. Motors
1/100 to ½ H.P.

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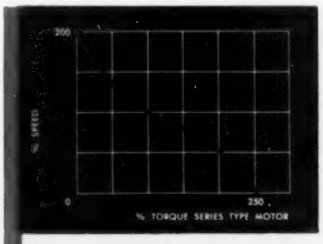
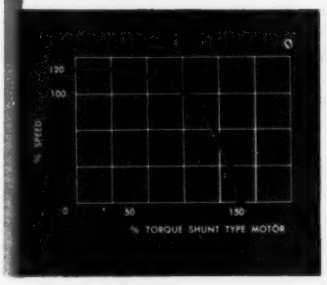
CHARACTERISTICS AND TYPICAL SPEED TORQUE CURVES OF BASIC HOWARD FRACTIONAL HORSEPOWER MOTOR TYPES

UNIVERSAL MOTORS



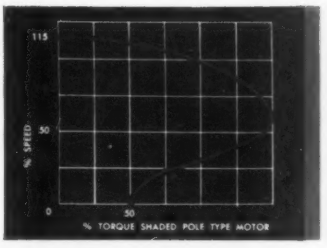
Series Type
Power: DC and AC 25 to 75 cycles.
1. High No Load Speed.
2. Full Load Speed (Optimum Performance) at approximately 50% no load.
3. Starting Torque high, 200 to 300% full load torque.
4. Variable speed, speed decreases with increasing loads.



Shunt Type **Power:** DC only.
1. No load and Full load speed are adjustable by winding or by armature and/or field voltage control. Approximately a 2:1 speed range can be obtained by field control, and 10:1 by armature control.
2. Fairly constant Full load speed.
3. Regulation varies from 10% to 30% depending upon duty and power requirements.
4. Starting torque, approximately 150 to 200% of Full Load.

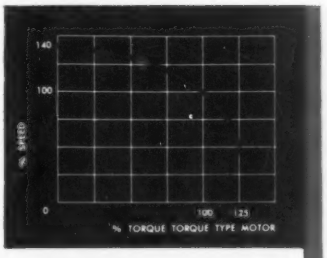
SHADED POLE MOTORS

Power: AC 50 to 60 cycles.
1. No load speed is determined by the number of poles with a No load slip of 3 to 5%.
2. Fairly constant Full Load Speed, with a full load slip of 10 to 20%.
3. Breakdown torque approximately 150% of full load.
4. Starting torque low, 50 to 75% of Full load.

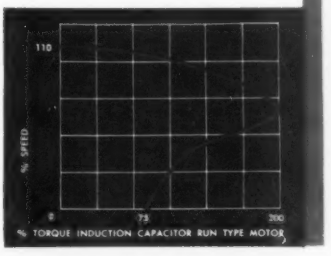


INDUCTION MOTORS

Torque Type
Power: AC 50 to 60 cycles.
1. No load speed is determined by number of poles, with a No load slip of approximately 5%.
2. Full load speed decreases with an increasing load. Designed to operate at approximately 30% full load slip.
3. No breakdown torque.
4. Startina torque high approximately 125% full load.



Capacitor Run Type
Power: AC 50 to 60 cycle.
1. No Load speed is determined by the number of poles, with a No load slip of 2 to 4%.
2. Constant full load speed, with a full load slip of approximately 10%.



Hysteresis Synchronous type
Power: AC 50 to 60 cycles.
1. Constant synchronized speed, determined by number of poles.
2. Starting torque equal to full load torque.
3. Quiet operation.

Reluctance Synchronous type motor
Power: AC 50 to 60 cycles.
1. Runs at a synchronized speed, determined by the number of poles.
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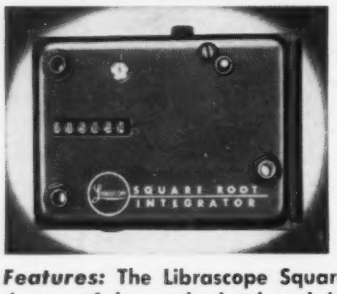
NEW SQUARE ROOT INTEGRATOR

Designed to Provide an Economical, Continuous, and Compact Integrator for the Automatic Totalization of Flow

Type: **Librascope Model 26 Square Root Integrator.**

Applications: **These integrators are specifically designed to assist in the computation of fluid flow where the orifice method of measurement is required. The Model 26 accepts the output of any differential pressure sensing device, and integrates the variable over a period of time (from one reading of the counter to the next), permitting accurate calculation of flow without the need of hand-planimetering charts. Model 26 units are recommended for use in the flow of fluids or gases where the pressure is held constant by regulators.**



Features: **The Librascope Square Root Integrator, through the use of the newly developed double disc and ball integrating mechanism, provides continuous integration, giving a higher accuracy; and combines compactness, high response, low maintenance, and low torque requirements. Pulse output provides for convenient electrical transmission for use in data systems or remote readout.**

Construction: **Unique in the use of super-finished tool steel discs and hardened steel balls operating in an oil bath.**

Size: **3 in. x 4.38 in. x 1.62 in. Weight 24 oz. Other Librascope integrating mechanisms are Ball and Disc Integrator, Linear Integrator, Flow Computer, Sine Cosine Mechanism. Write for Catalog 10M-1. Address Librascope, Inc., subsidiary of General Precision Equipment Corp., 42 E. Verdugo Ave., Burbank, Calif.**

CIRCLE 4 ON INQUIRY CARD

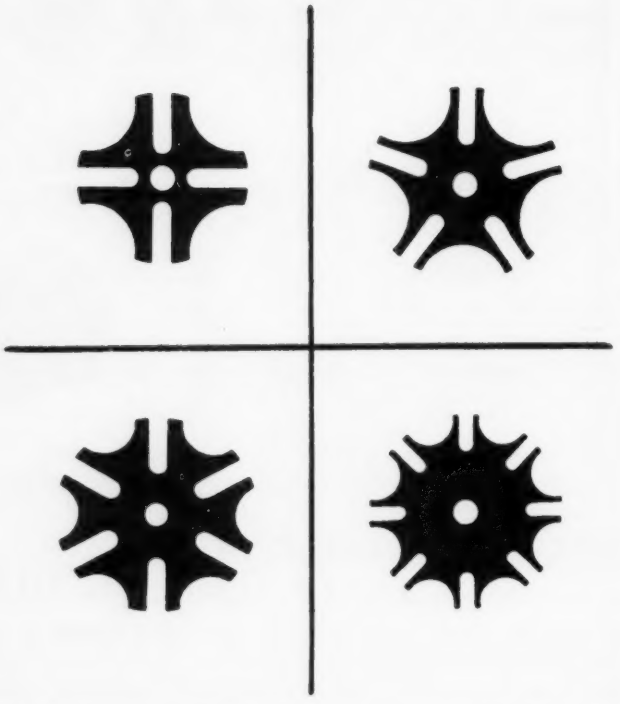


Fig 6—Four Geneva butterflies are shaped to provide 4 output shaft positions 90° apart, 5 positions 72° apart, 6 positions 60° apart, or 8 positions 45° apart.

or make other adjustments. A standard serrated coupling with three teeth missing can be used if foolproof indexing between the actuator and part being actuated is required.

VERSATILE BUTTERFLIES

Figures 1 and 2 show Geneva sectors shaped so that the output shaft will positively assume one of two positions 90° apart; and Fig 5 illustrates in steps the operation of a sector shaped so that the output shaft will assume one of three positions 45° apart. However, use of a complete Geneva escapement—called a Geneva butterfly instead of just a sector—permits many different configurations of the basic actuator. They can stop in as many as eight positions 45° apart, 6 positions 60° apart, 5 positions 72° apart, or 4 positions 90° apart (Figure 6). By appropriate motor field switching, the actuator output shaft operates in either clockwise or counterclockwise direction or in both directions.

Approximately 1.25 seconds is required for the actuator to move from one position to the next consecutive position. If a position is selected which is not adjacent to the starting position, the actuator requires approximately 1.85 seconds for each intermediate position it passes through. Average running current is 3.0 to 4.5 amperes.

All actuators except multi-position reversible units require one circuit connection only for each stop position. Special control switches permit automatic switching of the field circuits, and actuator rotation is determined by the direction of rotation of a switch handle. This is exceptionally desirable when the actuator is used in conjunction with fuel valves.

"Geneva-Loc" (registered trademark) is adaptable to hydraulic selector valves, engine controls, auxiliary engine throttles, air gates and ventilation controls, fuel selector valves, non-modulating installations (more than two, evenly spaced, fixed position) and similar applications.

Circle No. 39 on Inquiry Card

High-Pressure Valves

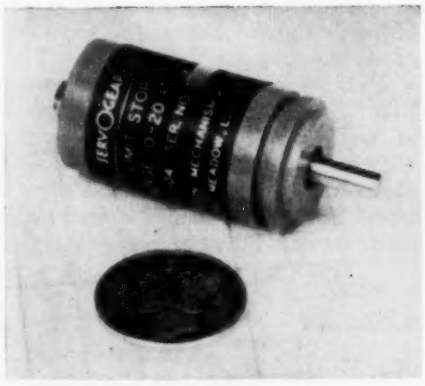
Direct solenoid-operated valves using "Shear-Seal" design, a self-aligning sealing ring in direct contact with a mating slide, are available for industrial applications where leakage specifications are critical. Metal-to-metal sealing surfaces continue to lap themselves indefinitely. Having either standard or explosion-proof solenoid housing and available in four-way, three-way, shut-off and diverter flow patterns, the valves operate on 12, 24 or 125 volts d-c. The valves are rated for oil and water pressures at 0-250, 0-1500 and 0-3000 psi. Air valves are rated at 0-250, 0-1000 and 0-1500 p.s.i. Barksdale Valves, Los Angeles, California.

Circle No. 209 on Inquiry Card

Small Nonmechanical Chopper

A one gram transistorized nonmechanical chopper, ½ inch long and ¾ inch in diameter, is solidly encapsulated to withstand shocks of 2000 g for 11 msec, vibrations of 30g up to 2000 cps and acceleration of 5000g. Usable either as a modulator or a demodulator, the chopper can be driven from d.c. to hundreds of kilocycles, symetrically, nonsymetrically or randomly. Switching circuitry provides stability and freedom from drift over temperature range, −40C to +80C. Solid State Electronics Company, Van Nuys, California.

Circle No. 111 on Inquiry Card



Multiturn Limit Stop

Sub-miniature, multiturn, infinitely adjustable limit stop is 0.625 inch in diameter, 1-7/32 inches long, synchro mounted, and has a torque rating of 18 ounce inches. Smallest of a standard line of mechanical limit stops, it can be set to limit rotation to any angle from 0 to 20 revolutions by means of an external screw at the end of the unit. A predesigned component for the miniature mechanisms field, the new stop's precision ball bearings provide low starting torque. Precision Mechanisms, Corp., East Meadow, New York.

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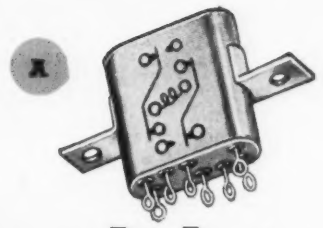
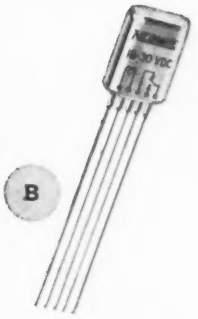
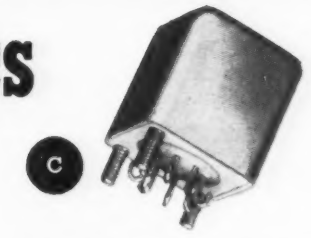




sub-miniature relays with high performance characteristics



A
MV
crystal can size

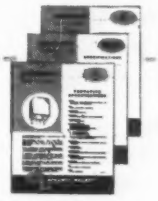
Vibration: 10 to 34 cycles per second at maximum excursions of .4". 34 to 2000 CPS 20G's acceleration.
Weight: 0.45 ounce (max.)
Size: .875" high x .797" wide x .359" thick max.
Pull-in Power: 250 milliwatts at 25°C.
Contact Rating: 2 Amps resistive at 32 VDC or 115 VAC.

B
NM
the famous NEOMITE

Vibration: 10 G to 500 cps.
Weight: .09 oz.
Size: H: .530" ±.015; W: .392" ±.010"; D: .196" ±.010"; Lead length: 1.5" ±.0625".
Pull-in Power: 100 Milliwatts.
Contact Rating: .25 Amp at 28 VDC resistive load.

C
... and announcing the brand-new
VG

Vibration: Low Frequency—10 G's, 10-55 CPS (total max. excursion, .06").
High Frequency—15 G's, 55-2,000 CPS.
Weight: 1.5 ozs., approximately.
Size: ⅞" ±1/64" sq. x 1⅛" ±1/64".
Pull-in Power: 340 Milliwatts at 25°C.
Contact Rating: 5 Amps at 26.5 VDC or 115 VAC, 60 Cycles resistive load.
Shock: 100 G's, per MIL-R-5757C, Shock Test II.



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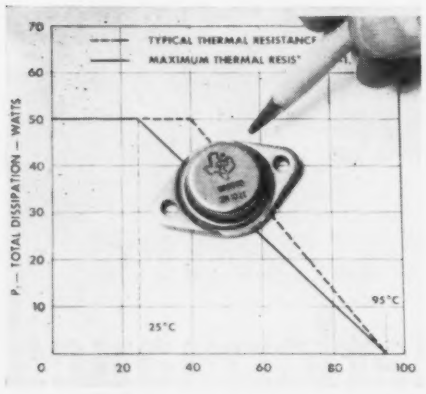
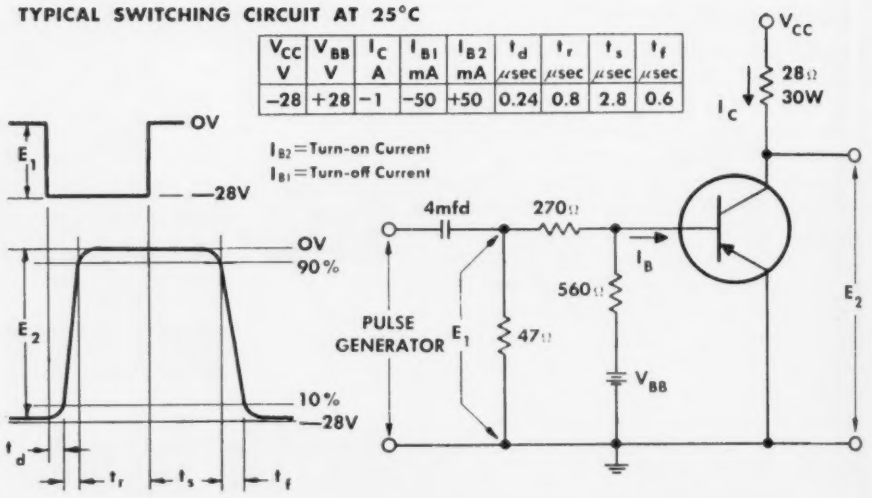


Plot shows thermal resistance characteristic of high voltage germanium power transistors. With a 100 volt rating, it has a 700 microampere collector cutoff current at one-half rated voltage.

TYPICAL SWITCHING CIRCUIT AT 25°C

V_{CC} V	V_{BB} V	I_C A	I_{B1} mA	I_{B2} mA	t_d μsec	t_r μsec	t_s μsec	t_f μsec
−28	+28	−1	−50	+50	0.24	0.8	2.8	0.6



Four units in each of two series of switching P-N-P alloy junction germanium medium power and power transistors have voltage ratings of 40, 60, 80, and 100 volts and identical switching characteristics. "On" time, the total of both delay time and rise time is 1.1 microseconds, the storage time is 2.8 microseconds, and the fall time is 0.6 microseconds for all eight units.

NEW SEMICONDUCTOR DEVICES

Silicon Switching Transistors, Temperature Probes, Voltage Regulators and Germanium Power Transistors.

Recent advances in solid state technology have spurred the development and production of many new semiconductor devices. Texas Instruments Inc., a major contributor to the field, recently announced a variety of such semiconductor products:

• Two new silicon switching transistors with switching times as low as 500 millimicroseconds in saturating circuitry have wide use in high speed computers and other switching applications requiring high reliability over wide temperature ranges.

• In a unique application of silicon, a solid state temperature probe is distinguished by a positive temperature coefficient that results in a constant rate of change on the order of .7%/degree centrigrade along a retraceable curve.

• Advanced silicon 10-watt double-anode voltage regulators and 400 milliwatt glass reference diodes provide the industry with the highest power available in an inline glass package.

• Four new intermediate power silicon transistors bridge the gap between commercially available high and medium power silicon transistors.

• Diffused base germanium transistors built for use in horizontal and vertical cathode ray tube deflection circuits combine for the first time high power performance (15 watts) and high frequency operation (12 megacycle alpha cutoff frequency) in the same package.

• Two P-N-P alloy junction germanium power transistors have the highest voltage ratings in the industry. Differing only in voltage ratings, the 120 volt 2N1022 and the 100 volt 2N1021 feature guaranteed 700 microampere collector cutoff currents at one-half rated voltage, a two mill I_{co} at full rated voltage, and a typical beta of 70 at one ampere and 23 at five amps. The design center saturation resistance of each device is 0.08 ohm while the typical drive voltage is 1.3 volts at five amperes collector current. Because of their high performance characteristics at high voltages, they are ideal for use in power supplies and audio, servo and power amplifiers.

• Four germanium medium power transistors exhibit a 20-60 beta spread at 50 mills and dissipate 800 mw.

• Four germanium power transistors dissipate 5.5 watts at 25C and show a 20-60 beta spread with a 3 amp maximum current rating.

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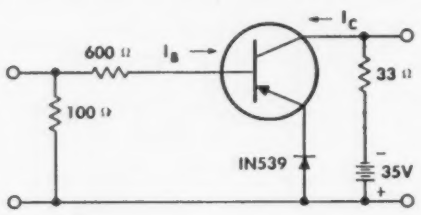
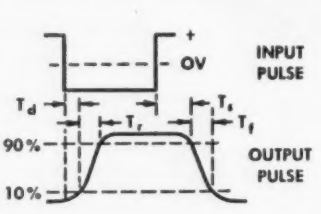


TYPICAL SWITCHING TIMES

T_d	DELAY TIME	0.3 μsec
T_r	RISE TIME	0.7 μsec
T_s	STORAGE TIME	1.2 μsec
T_f	FALL TIME	0.5 μsec



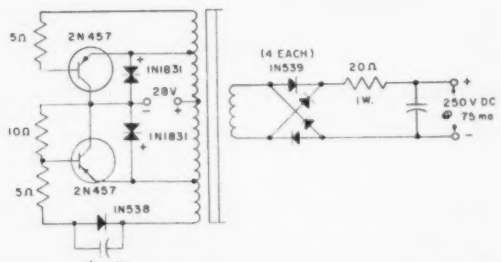
TEST CURRENTS

I_{B1} (Turn-on Current) = − 30mA

I_{B2} (Turn-off Current) = + 30mA

I_C (Collector Current) = − 1A

Graph illustrates typical switching characteristics of diffused base germanium high frequency/high power transistors. A unique characteristic of the 2N1046 requires a new parameter to describe its operation. Termed "internal cutoff frequency", this parameter is defined as the point at which forward current transfer ratio equals unity; figure averages 10 megacycles for the 2N1046.



Typical protection circuit uses 2 double-anode stud-mounted voltage-regulators. Dissipating 10 watts, they are available in 22 to 91 volt ratings in five or ten percent tolerances. Power handling capabilities of the devices make them particularly well suited for surge protection of power transistors. Regulator breakdown voltage is just below the zener voltage of the transistor so that it will shunt surge peaks. This double-anode feature enables them to protect either N-P-N or P-N-P silicon voltage regulators and reference diodes.

New 3-Way Nylon-Body Solenoid Valve...

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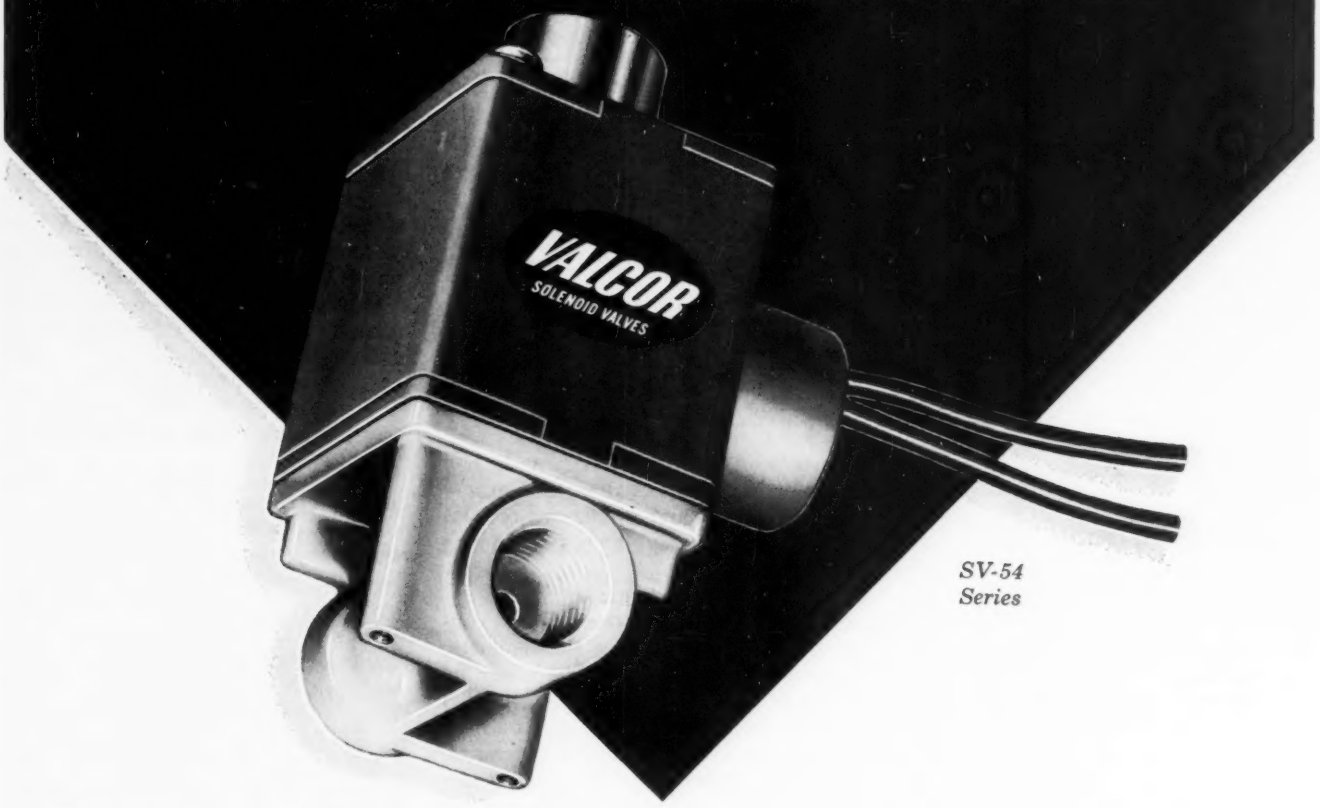

SV-54 Series

VALCOR'S new 3-way Nylon solenoid valve, SV-54 Series, outlasts and outperforms steel, yet is list priced as low as $10.75! In general purpose and O.E.M. installations, where millions of operating cycles are essential, this new Valcor valve not only works best but costs less.

Its nylon seat outlasts steel...its port threads outlast steel . . . pound for pound it's *3 times stronger than steel.* Dry seal threads, no compound is needed—and they won't loosen even under severe vibration. Nylon is non-corrosive so you have no atmospheric problems. And the stainless plunger is a reliable workhorse for millions of cycles. Bubble tight sealing. Available in normally open, normally closed and "directional control" configurations in all normal AC and DC voltages...1½" square x 3" long (valve illustrated).

Write today for complete technical data on this shock-resistant, pressure-proof valve—the 3-way nylon-body valve, SV-54 Series, that's 3 times stronger than steel, yet costs less. Try it on your toughest application.

VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

365 Carnegie Avenue, Kenilworth, New Jersey

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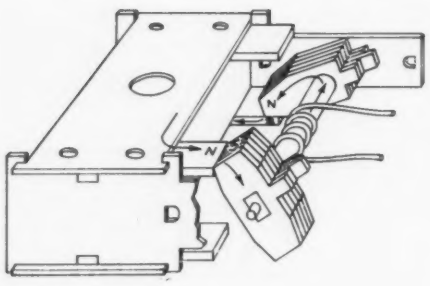

Built-in permanent magnet provides a magnetic field which holds the MTR in either of its two normal positions, without the use of holding current or mechanical latching. This action, called "magnetic detenting", is accomplished by having the coil positioned coaxially with the rotating armature. The armature serves as a keeper across the permanent magnet when the MTR is in either of its two normal positions. Actually, the permanent magnet acts as a permanent magnetic reference, or bias, with relation to the magnetic field set up by the coil. Since the armature is coaxially positioned to the coil, the armature extremities will be given a magnetic polarity dependent upon the direction of current in the coil.

MAGNETIC TOGGLE RELAY

Magnetic Detenting Dispenses with Mechanical or Electrical Holding Power

In 1819 a Danish physicist, Hans Christian Oerstad, started the accumulative development of the electromagnetic relay by discovering that a wire carrying an electric current produces a magnetic field. In 1822 Andre Ampere, a French scientist, made another contribution: he found that a spiral, or helix, of wire concentrated the magnetic field. Ampere, incidentally, first coined such words as electromagnetic, electrodynamic and electrostatic. And it was Joseph Henry, an American, who used the electromagnetic relay in the construction of a telegraph system during the 1830s.

So it was that the electromagnetic relay was developed by these three scientists—aided of course, by many others. But there the story stops, says American Monarch Corporation of Minneapolis, Minn., for there has been no major change or improvement in the relay since that time. They grant that many individual improvements have been made in such things as insulation, contacts, balancing, operating range and dust sealing, but the basic operation of the relay has not changed or been improved upon for over 100 years. Conventional relays still consist of a coil wound over a magnetic material having a moving portion, spring loaded, which by mechanical motion moves a switch assembly when a current is passed through the coil. The switching action is sustained only as long as the coil is energized.

Now the American Monarch Corp. claims the first major improvement in relay design—the Magnetic Toggle Relay—Their MTR is held in either of its two normal positions by "magnetic detenting" which is not dependent on mechanical latching or electrical holding power. With the same coil, the new relay operates in as little as 3 milliseconds from a-c or d-c voltage and from 1 to 120 volts.

CONVENTIONAL RELAY LIMITATIONS

"Of course," says American Monarch, "many persons might ask . . . 'So the present day relays are 100 years old, aren't they good enough? Don't they do the job? . . . Won't they work where we want them to?' " . . . American Monarch's answer is NO . . . and, they say, anyone who has designed around the weaknesses and limitations of conventional type relays knows this to be true.

Here are the limitations:

- Applying power to the coil of a conventional relay energizes the magnetic system. Not only must this power be sufficient to "pull-in" the spring loaded contact assembly, it must also be high enough to overcome contact pressure and other external forces such as acceleration, vibration or shock. These factors make it difficult to design a conventional relay to operate reliably on transistor pulse circuits, capacitor storage or under momentary voltage conditions.
- Once the contact assembly of a conventional relay has been actuated, power must be continuously applied to hold the relay in its energized position. To avoid overheating, practical limits usually call for holding power of not more than twice the pull-in power, resulting in narrow operating ranges and narrow reliability limits. Furthermore, if for any reason the voltage falls below that necessary to hold the relay, it will "drop out" and return to its unenergized position.
- When power is removed from the coil, the contact assembly drops out. This drop-out point is unreliable since it is governed by a declining set of conditions affected by residual characteristics of the magnetic system.
- A conventional relay operates only on the type of power for which it is designed. For instance, a d-c relay will not operate well with a-c power; an a-c relay will not operate with d c pulse; a 6 volt relay will not operate well with 100 volts; a 60 cycle relay will not operate well with 400 cycles.
- Because of design requirements and physical limitations, the speed of operation is quite slow when compared with other electronic equipment and circuits with which they can be used.
- Relays of the moving or clapper type rarely approach any form of static or dynamic balancing. Furthermore, when the conventional relay is in an unenergized position, it may be unstable and unreliable because of the "loose" nature of the mechanical spring arrangement. Such an arrangement may allow contacts to bounce or touch under acceleration, vibration or shock.
- Adding more contacts or increasing contact pressure requires additional operating power. There is a limit to that design which involves pull-in power, holding power, drop-out point and contact assembly structure.

THE MAGNETIC TOGGLE RELAY

AMC offers a solution to the above design limitations for a wide variety of circuit design and application possibilities. They compare the operation of the MTR with that of an ordinary toggle switch. Just as a momentary "pushing" force on a toggle switch handle causes it to toggle to one of its two normal positions, a pulse of positive polarity causes the MTR to toggle to one of its two normal positions. Likewise, just as a momentary "pulling" force on the toggle switch handle causes it to toggle back to its other normal position, so does a negative pulse cause the MTR to toggle to its other normal position.

DIFFERENCE BETWEEN MTR AND CONVENTIONAL RELAY

This comparison points out the principle difference in operation between the conventional relay and the MTR. Pulses of a certain minimum magnitude drive the MTR to one of its two normal positions—both positions being fully "energized" without use of holding current.

Since the polarity of the permanent reference does not change, and the polarity of the armature does change, a repellent or attractive force can be exerted on the armature to cause its rotary motion. When a momentary electrical input establishes a field in the

armature which opposes the permanent-magnet field, the armature is repelled from one pair of poles and is attracted to the other pair, causing the MTR to toggle instantly. If the momentary input establishes an aiding field, the armature is not affected and the MTR remains in its existing position.

The MTR, says AMC, offers the designer a variety of possibilities: any type of coil; any type of contact assembly; a magnetic memory; no holding power; no drop-out point; extremely fast operation; well balanced and stable design; reliable operation; a wide variety of inputs with any one coil; and it will generate a pulse by mechanically actuating the assembly.

For information on circuit design applications
Circle No. 61 on Inquiry Card

WORTH FILING

Packaged Amplifier

16 pages of facts, figures and photos describe how a new packaged amplifier combines a new level of circuit flexibility with the reliability of computor-grade printed-circuit operational amplifiers. Mechanical and performance characteristics are thoroughly covered. Other sections of the booklet tell how to put the general-purpose, utility package to work in industry and laboratory instruments and suggest applications.

Source: George A. Philbrick Researches Inc. Boston, Mass.

For your copy: Circle No. 192 on Inquiry Card

Pressure Transducer

A dual-coil variable-reluctance pressure transducer, designed for rugged environments met in missile applications, has very low sensitivity to shock, vibration and acceleration. Differential, gage and absolute models are available with numerous pressure ranges from 0-5 psi to 0-3000 psi and ± 2 psi to ± 300 psi.

Absolutely symmetrical construction of the gage halves prevents overshoot when simultaneous pressures are applied to both sides. High overload rating and a high diaphram-burst pressure allows the gage to be used in applications where high transient overpressures are present. Ultradyne, Inc., Albuquerque, New Mexico.

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Refrigerant Coupling

An improved self-sealing coupling designed for use with commercial and residential air conditioning and refrigeration applications is suitable for use with numerous refrigerants, including F-12 and 22 similar compounds. Leakproof, the coupling permits factory testing and precharging of air conditioners, which may then be shipped and stored fully charged with refrigerant. When disconnected, the coupling halves seal tight to prevent loss of refrigerant and admission of air or foreign particles into the refrigerant system. Aeroquip Corporation, Jackson, Michigan.

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Phase-Sensitive Demodulator Preamplifier

Phase sensitive demodulator, whose d-c output voltage is proportional to an in-phase or 180° out-of-phase component of an a-c signal with respect to a reference, is a compact, self-contained unit designed for use with optical oscillographs, oscilloscopes, tape recorders, etc. Precision measurement is the result of such characteristics as: negligible quadrature signal error, provision for floating signal and reference inputs, and front panel VTVM for accurate calibration signals. It accepts outputs from resolvers, synchros, differential transformers and other transducers.

Sensitivity is 5 mv in-phase to produce 1 volt under maximum output load conditions and frequency response is 3 db down at 20% of carrier frequency. Carrier frequency filter is selected by a three-position switch—60, 400 or 1000 cycles, with 5 KC optional. Quadrature rejection ratio is better than 100:1, drift is less than 0.1% of full scale per hour and operating voltage is 115 volts, 50-400 cycles.

The system is unit packaged in individual, portable cases 11 5/8″ high, 5 5/16″ wide, and 19 11/16″ deep. These preamps can also be rack mounted in four-unit modules in a 19″ frame. Industrial Division, Sanborn Co., Waltham 54, Mass.

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reliability

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INSTRUMENT CORP.
THE SERVO SPECIALIST

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NEW SERVOMOTOR

DYNAMIC's new A/C Servo Motor, developed for the Navy Bureau of Ordnance

- High torques at low control field power.
- Exceptionally rapid response.
- Fast stall acceleration.
- Superior internal damping.
- Rigid adherence to military requirements.
- Very low cost – due to radically simplified design.

Miniature 60 cycle Servo Motor, Size 11 Model M-100 (4 Frame Sizes: 5, 8, 10, 11) Pat. Pend.

MECHANICAL CHARACTERISTICS	
Rotor Inertia (gm-cm²)	1.4
Torque at Stall (oz. in.)	.73
No Load Speed (rpm)	1450
Time Constant (SEC)	.005
Theoretical Stall Acceleration	35,000 (RAD/SEC²)
Operating Temperature Range	400°F.
Damping (DYNE-CM-SEC)	300.

ELECTRICAL DATA	FIXED PHASE	CONTROL PHASE
Voltage	115	115
Current (Stall)—MA	42	42
Power (Stall)—Watts	3.5	3.5
Effective R (Stall)—Ohms	3800	3800

NEW MAGNETIC CLUTCH

DYNAMIC's Magnetic Clutches, Brakes, and Clutch Brakes offer exceptionally high torques and long life.

- Highest output torques.
- Low control power.
- –85°F. to 400°F. operation temperature range.
- Fast response time.
- Extra long life under full rated loads.
- New design provides outstanding reliability.

Model D-103 Size 11 Clutch
(4 Frame Sizes: 11 models in each frame size)

TYPICAL CHARACTERISTICS	
Output Torque	65 oz. in.
Breakaway Torque (energized)	.10 oz. in.
Breakaway Torque (de-energized)	.03 oz. in.
Inertia (outer shaft)	5.1×10^{-6}
Inertia (inner shaft)	4.7×10^{-6}
Backlash (engaged)	0
Power Consumption	3 watts
Response Time	As low as 3 millisecs
Weight	4.2 oz.
Max. Recommended Speed	10,000 rpm

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CIRCLE 7 ON INQUIRY CARD

GEAR PUMP

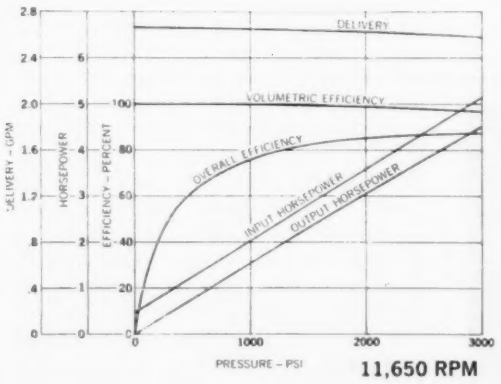
Cartridge Construction Frees Hydraulic Pump from Mechanical Drag

Utilizing a cartridge construction with hydraulically and thermally controlled positive clearances, designers of a fixed displacement cartridge type gear pump have been able to eliminate the usual gear pump "mechanical drag" for all pressures and operating conditions including starting. Elimination of gear pump drag permits operation at speeds well beyond the range of conventional gear and piston type pumps.

Stating that their pump represents a major advance in gear pump design and manufacture, Adel Precision Products, a division of General Metals Corporation in Burbank California, explained that with only two moving parts in the pump proper, efficiencies can be reached that were formerly obtainable only in the more complex piston type pumps. The cartridge contains two diametrically opposed centerplates set at assembly to provide optimum radial and gear clearances at both the inlet and discharge sides of the gears. Clearance at the ends of gears is initially set by precision control and selection of the width of both centerplates and both gears. At one end of the cartridge, a hydraulic pressure balancing button cancels out internal hydraulic forces and prevents cartridge end-plate deflection. With this design the gear end clearance is maintained constant throughout the pressure range.

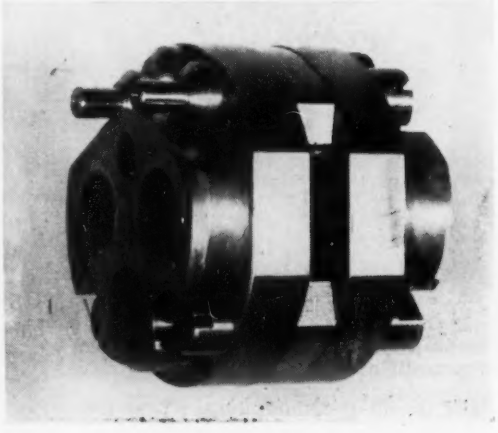
Bearing loads in this type of pump were reduced by a design in which the pressure centerplate shrouds the outside diameter of the gears practically to the point of outside diameter intersection. Thus the area over which full and gradient hydraulic pressures are exerted on gears and cartridge end-plates is severely limited and localized. Thus the design not only reduces gear journal loads appreciably but permits the use of a pressure balancing button at the end of the cartridge to prevent the cartridge end-plate deflection.

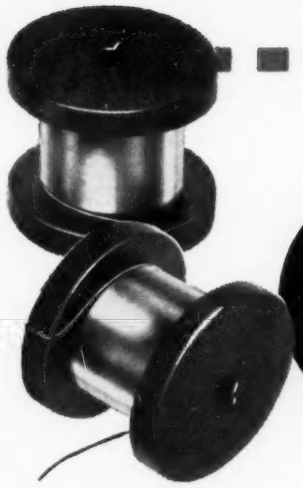
Circle No. 57 on Inquiry Card



Plot shows performance characteristics for a unit at 11,650 RPM; units operate at speeds up to 60,000 RPM and 3,000 PSI for missile applications. Higher speeds result in higher volumetric efficiencies since internal leakage is a time function and is independent of RPM. Increased speed means increased output horsepower per pound of pump weight since output GPM and horsepower are directly proportional to RPM. Pump may be directly coupled to high speed drives such as air and hot gas turbines to result in a smaller power package.

Pump incorporates special inlet characteristics to prevent cavitation at high speeds and altitudes. Gear tooth spaces open successively to three separate chambers; inlet, boost and discharge. Large inlet porting permits fluid to enter the tooth spaces both radially and axially for nearly one quadrant on each gear. Cartridge housing also serves as an inlet booster chamber; hydraulic pressure of this chamber is set by a spring loaded valve thru which internal leakage fluid must pass before entering the inlet chamber. Leakage fluid is forced into the tooth spaces if pump tends to cavitate eliminating or reducing this condition.





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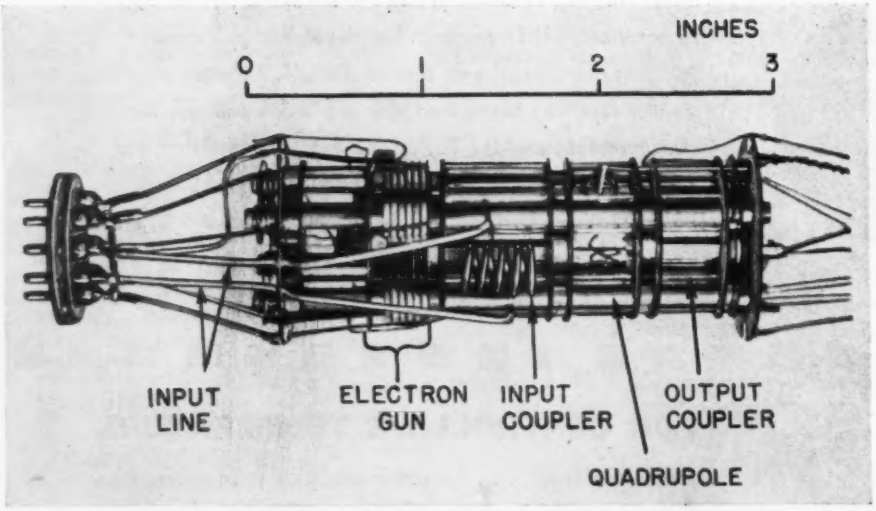


In the fast wave parametric amplifier, an electron gun, similar to the gun used in picture tubes, generates an electron beam of about 35 microamperes which drifts at very low velocity—corresponding to only 6 volts—along the lines of a 200 gauss magnetic field. Input and output couplers are pairs of deflection plates tuned to the signal frequency (560 megacycles) by built-in coils. Signal power applied to the input coupler is transformed into spiraling electron motion which is amplified during passage through the quadrupole electrode. A pump supplies the quadrupole electrode with 10 milliwatts power at 1120 megacycles. In the output coupler, electrons spiral inward, giving up their kinetic energy to the load circuit.

FAST WAVE PARAMETRIC AMPLIFIER

New Concept, New Tube

Random molecular and electron motion in materials, exclusively a function of temperature, causes deterioration of radio reception at low signal levels. Because engineers observed this effect first in audible form in radio receivers, it acquired the designation "noise". "Snow" which appears on television screens in fringe areas is a visible form of the same phenomenon. In radar receivers, the same "noise" hides target pips. While some noise is unavoidably associated with receiving equipment, conventional amplifiers fall far short of theoretical optimum in this respect.

Zenith research physicists headed by Dr. Robert Adler, the company's associate director of research, in cooperation with Dr. Glen Wade of Stanford University have introduced an amplifier tube based on new concepts involving the removal of noise from a fast wave on a stream of electrons that carries the signal, and subsequent parametric amplification of that wave.

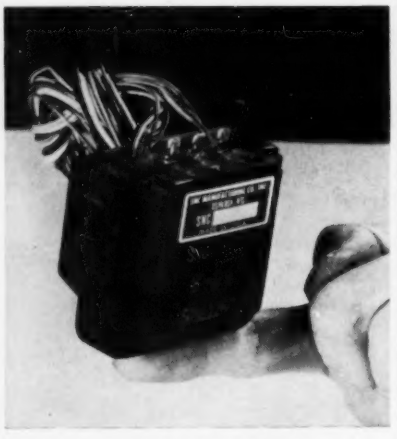
According to Dr. Alexander Ellett, vice-president in charge of research, the new development utilizes an idea advanced by Dr. Adler in which the fast-wave mode of motion on an electron beam permits interchange of input signal and beam noise in a coupler. In conventional amplifiers all external power is supplied in the form of direct current, and the fast wave cannot be used. In the new Zenith amplifier, Ellett said, the fast wave is amplified with the help of externally applied alternating fields—a method which is one form of what has recently come to be called parametric amplification.

An electron gun in the tube, Ellett explained, generates an electron beam which enters an input coupler with some random motion. The fast wave component of this motion is given up to the input coupler and transformed into heat in the resistive portion of the signal source. At the same time, the beam absorbs signal energy and carries it in the form of a fast wave, thus interchanging beam noise and input signal. The spiraling electron motion which carries the signal is amplified during passage through a quadrupole electrode and produces a highly non-homogeneous transverse electric field of fourfold symmetry. One component of the alternating non-homogeneous field pattern in the quadrupole appears to revolve in synchronism with the spiraling electrons; this causes the radii of their orbits to increase exponentially, depending upon their phase at the instant of entry. When the two processes are averaged, exponential growth always outweighs exponential decay and gain results.

Ellett pointed out that regardless of how the signal frequency is altered, individual electrons always spiral through the quadrupole at a rate of rotation determined by the magnetic field. As a result, the signal frequency does not affect the amplifying process and the bandwidth is limited only by the input and output couplers.

With a noise figure of 1db and a gain up to 30 db, the tube is a scant four inches long and is relatively simple to produce and operate. Ellett said that the amplifier will greatly extend the effective range of military defense radars and missile and earth satellite tracking systems and that it can also be used in equipment for long-range communications. Use of the tube in the field of VHF and UHF television could produce substantial reception improvements in marginal reception areas.

Circle No. 64 on Inquiry Card



Miniaturized Transformer

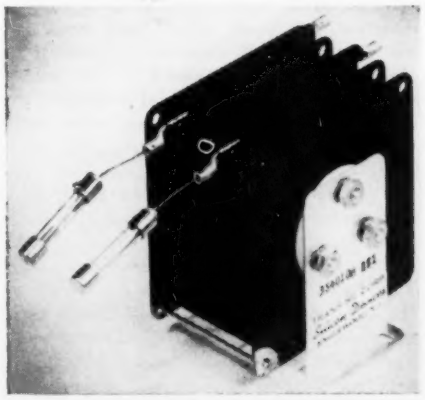
When a large electrical manufacturer decided to make a substantial reduction in the size of a mobile-radio unit, all components in the transistor-powered set had to be reduced in both weight and size. Transformers weighing 7-lbs and occupying 28-cubic inches were in use with the old unit. By utilizing "C" cores developed by Arnold Engineering of Marengo, Illinois, instead of laminated cores, the weight was cut to one pound and the volume to 4.75-cubic inches without any loss in the hundred-watt transformer's performance.

Circle No. 119 on Inquiry Card

High-Beta Silicon Transistor

A new high-beta silicon transistor offers current gain of 80 to 200. Useful beta can be maintained even at reduced collector-current levels and over a temperature range of −65C to 150C. Offering more gain per stage, these transistors reduce the number of amplification stages required. In amplifiers where stability of gain is essential, degenerative feedback may be used to hold beta variation with-in plus-or-minus ten percent. Transitron Electronic Corporation, Wakefield, Mass.

Circle No. 108 on Inquiry Card



Self-Protecting Rectifiers

A self-protecting silicon rectifier, eliminates the need for high-cost protective devices. Formerly, silicon and germanium rectifiers required expensive, quick-acting fuses to protect them against overloads and short circuits. Diffused silicon power rectifiers can withstand short circuits if protected only by commercially available fuses and are hermetically sealed cells for magnetic amplifier and power supply applications. Additional characteristics include up to 99% efficiency depending upon application, a regulation characteristic of less than one volt per cell forward drop, reliable operation without derating in the temperature range of −65C to +150C and a low, reverse leakage measured in microamperes at rated inverse. Trans-Sil Corp., Englewood, N. J.

Circle No. 105 On Inquiry Card

WORTH FILING

Sealed Relays

24 page bulletin contains information on hermetically sealed relays for military and general-purpose industrial application. Photographs, circuit diagrams, coil data, and specifications for micro-miniature, sub-miniature, miniature, and high-speed relays are included.

Source: General Electric Co.
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For your copy: Circle No. 247 on Inquiry Card

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D. C. TORQUE MOTORS

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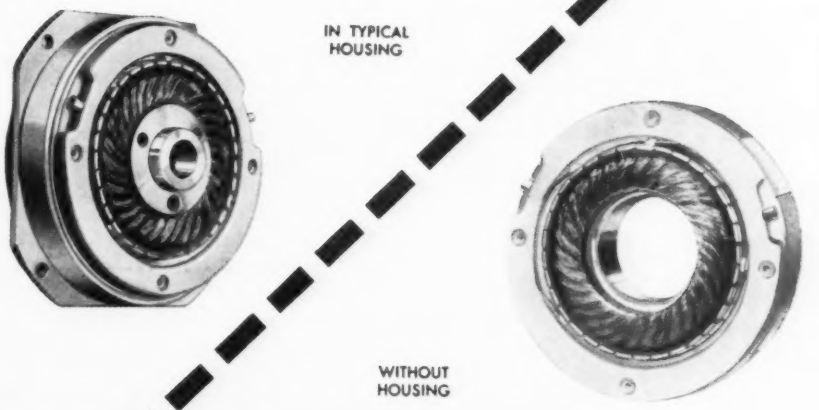

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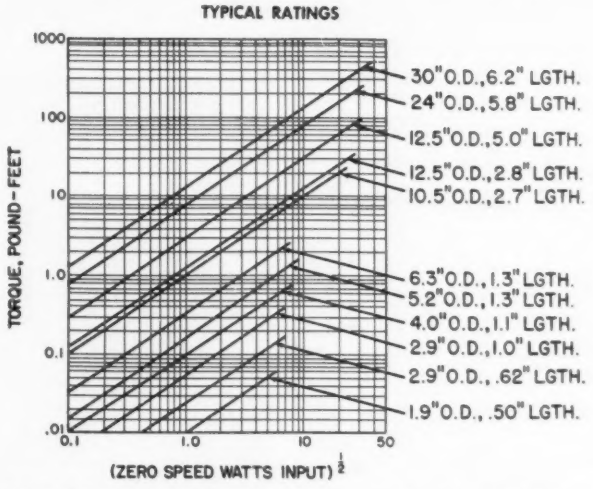

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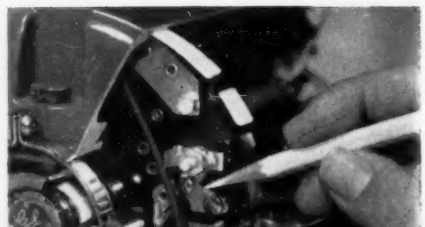
CIRCLE 9 ON INQUIRY CARD

FHP MOTORS

Major Changes In FHP Motors Reduce Assembly and Maintenance Costs

The first major improvements in General Electric's fractional horsepower motors since their introduction will enable manufacturers and users to reduce assembly and maintenance costs in more than 1,000 different applications. Major improvements include:

- Plug-in quick-connects for all terminals cut wiring time in half.
- Reversal of two plug-in leads changes direction of rotation.
- Brass links simplify voltage change on dual-voltage motors
- An enlarged wiring compartment and a narrower terminal box, which provides additional clearance for leads brought in through the conduit opening, permit fast hook-up during installation.
- An anti-rust treated shaft and bright-plated hardware protect the motor against corrosion. Special "gun metal" anti-corrosion treatment given to the motor's entire shaft simplifies maintenance and service by making fans, pulleys and couplings easy to remove even under high humidity conditions. Improved plating maintains a continued bright finish for the base latches and other hardware.
- New bonding method insulates the stator winding and metal clamps for uniform core alignment.



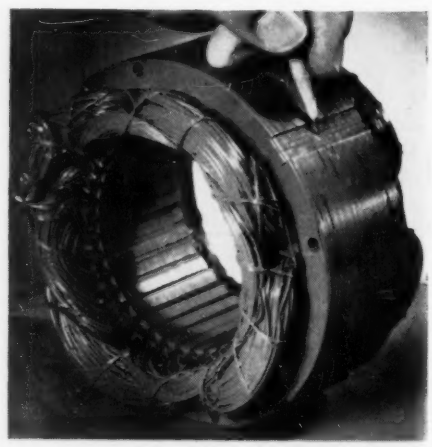
Wiring time during installation can be cut in half with the plug-in quick-connect terminals which are used for all internal and external connections. Studs have been retained on the terminal board for conventional wiring if the quick-connect devices are not used. Sliding two small brass links into position, changes the voltage on dual-voltage motors. This can be done with a screwdriver without removing the links by adjusting four screws and sliding the interlocking connections into place. The links assure fast and easy voltage change without confusion. Shaft rotation can be reversed in a matter of seconds without tools by interchanging the two plug-in motor leads.

- New lug design into the end shield just inside the terminal box opening conveniently connects to ground for applications in sump pumps, home workshop tools, power lawn mowers and some farm equipment.

The new features are available, where appropriate, on split-phase, capacitor-start, permanent-split capacitor and polyphase Form G motor types. General Electric Co., Schenectady 5, New York.

Circle No. 53 on Inquiry Card

A special composition washer cushions the switch click during opening and closing of the centrifugal mechanism. The quietly operating mechanism is particularly desirable for residential applications such as furnace fans.

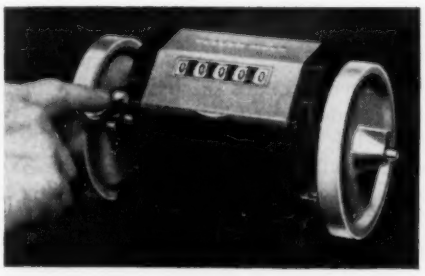


New varnish treatment bonds stator core and windings into a unitized component that resists heat, aging, moisture and stresses. Uniformly aligned core laminations are fastened with metal clamps for high rigidity.

Turret-Packaged Servo Components

A new packaging method groups precision rotating servo components in miniature turret packages. Unlike conventional rotating component packages which line up the components end-to-end, the turret concept requires less volume, is better suited to environmental conditions such as vibrations, shock, etc., and permits greater flexibility of use for the components. For example, a motor can drive more than one component, at either the same or different gear ratios, and the output shaft makes possible easy connection to other components or subassemblies. Servomechanisms, Inc., Mechanical Div., Westbury, L.I., New York.

Circle No. 101 on Inquiry Card



Quick-Reset Revolution Counter

High-speed quick-reset geared revolution counter, designed for general purpose work where speed and ease of reset are important, will accept speeds up to 6000 rpm or 8000 counts per minute. A flick of the lever through a 60-degree arc resets the counter to all zeros. Large figures provide excellent visibility at extremely wide angles, making the counter highly desirable for in-line reading. Veeder-Root, Inc., Hartford, Conn.

Circle No. 107 on Inquiry Card

Toroidal Power Transformer

20-watt toroidal transformer is designed for stacking, or printed circuit boards. Standard units, each with a primary of 115 volts, 400 cps, are available for filament use, synchro drive, isolation, and plate voltage. Any output can be supplied from 0 to 1000 volts and up to 3 secondaries are provided, with taps as required. These units have a 6-32 threaded insert for printed circuit boards, or they can be supplied with center holes for stacking on a single screw in chassis mounting. Size of these transformers is 1⅝ inches O. D. x 1⅛ inches high; weight is 3.9 ounces Temperature range: from −55C to +100C. Arnold Magnetics Corp., Los Angeles, California.

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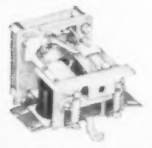
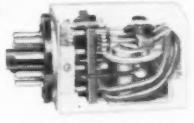
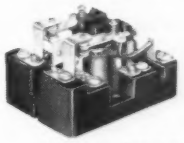


M.E.R. STEPPER

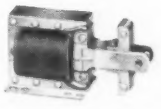
Micro-Miniature IR-1005 RELAY



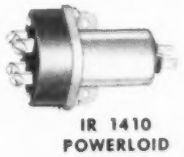
IR-1210 RELAY



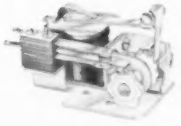
2200-U RELAY



NO. 16 SOLENOID



IR 1410 POWERLOID



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Newark Electric Company
223 W. Madison, Chicago 6, Ill.
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Interstate Supply Co.
4445 Gustine, St. Louis 16, Mo.
Burstein-Applebee Company
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2403 Farrington Dallas 7, Texas
Radio, Inc.
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Tiny time-division multiplexing switch. The Miniplexer weighs 2.37 ounces and is ¾″ long and 1¼″ in diameter. It has 60 contacts pins for 30 channels of break-before-make operation, provides service free life of 500 hours at 30 revolutions per second and operates under ambient temperatures of plus 125° C to —55° C and under vibration conditions up to 2,000 cycles at 25G.

TINY SAMPLING SWITCH

Miniaturization of Time-Division Multiplexer Follows Extensive Metallurgical Research

Development of contact pins of exceptional durability and low friction coefficient has made possible the severe miniaturization of a rotary sampling switch. Tradenamed Miniplexer, the switch is a result of an extensive metallurgical research program conducted by the engineers of Applied Science Corporation of Princeton.

ASCOP engineers wanted to retain in this miniaturized version of the switch, the output accuracy and 60 pin contact plate of earlier larger models. Reduction of the switch radius, with the resulting critically close positioning of contact pins, led to magnification of angular errors. Therefore, it was of paramount importance to prevent contact pin wear with its attendant rough running surface and high wiper wear. They also wanted the wiper and contact pins to be economical to produce.

Traditional coin silver contact pins, with their relatively short wear qualities, would not do the job. The metallurgical research program produced a metal material that had a high degree of surface hardness, good electrical properties and a low coefficient of friction.

ASCOP engineers first welded pin heads of this material to nickel silver shanks to form the contact pins, but the tips broke off in grinding during manufacture and the costs of the manufacturing process were high. To solve this problem, the contact pins were constructed of a solid rod of the new material. Pins fashioned from this material have been trademarked Durapoint pins.

They attempted to use wipers of traditional rectangular design. This approach required a stoning and filing operation with hand tools, and high cost and lack of standardization resulted. Next they experimented with a round wiper which could be precision-machined by standard machine tools and found it to be successful. The finalized design shows a reliability improvement of 2 to 3 times over the old design giving 500 hours of service free life at 30 revolutions per second and 2,000 hours of total life. Development of Durapoint pins makes possible a clearer, sharper, more stable pulse train output over an extended period.

ASCOP engineers believe that the switch will contribute significantly to the reduction of weight, size and power requirements in airborne and ground-based electronic systems.

Circle No. 67 on Inquiry Card

Hydraulic-Pressure Switch

An improved, aircraft, hydraulic-pressure switch is designed for use in hydraulic systems requiring a pressure sensor to actuate electricai apparatus. Either of two types of sliding piston hydraulic actuators—the lapped piston or the "O" ring sealed piston—can be supplied with the switch. Both types have a seepage chamber located between a high- and a low-pressure seal and vented to a return port. In addition, the pressure level at the return port will not affect the set point because of a balanced piston design which nullifies this pressure factor. This design minimizes the hydraulic fluid-loss probability. Switch operating-point is adjustable within the pressure ranges of 500 to 2,000 psi and 2,000 to 3,500 psi. Consolidated Controls Corp., Bethel, Conn.

Circle No. 103 on Inquiry Card

Announcing The 3rd Mars Design Contest

In the past Mars Outstanding Design Contests have attracted such wide interest that Mars Pencils is sponsoring another contest in 1959. Winning designers will again be paid $100 and will have their designs reproduced in the wide list of technical publications in which the Mars Outstanding Design Series appears. Design subject can be in the field of aviation, space travel, autos, trains, buildings, engineering structures, household items, tools, machines, business equipment—almost anything. Projects will be selected on the basis of appeal to design-minded readers, broad interest, attractive presentation. They should be submitted to: J. S. Staedtler, Inc. Hackensack, N.J.

Aircraft Sampling Switch

A new, 3-pole sampling switch for high-speed aircraft instrumentation and data reduction systems has collector rings for each pole in a separate hermetic connector and 30 BBM contacts per pole at 5 rps. Two poles scan differential thermocouple and strain gauge output signals; the third provides the timing function. Special metal brushes are driven through a suitable gear-reduction system by a 115-volt a-c, 400 cps, single-phase, 15 watt motor. Operating life is estimated at 1000 hours. Instrument Development Laboratories, Inc., Attleboro, Mass.

Circle No. 207 on Inquiry Card

WORTH FILING

Die Cast and Molded Plastic Parts

A new edition of "Small Parts for Industry" covers a variety of zinc alloy die cast and molded thermoplastic products. The bulletin is divided into two sections: Section 1—parts made to customers' specifications; and Section 2—standard products available from stock. Unusual die cast items covered in Section 1 are: "Intercast" products—movable, multiple-element units "cast-assembled" in one operation—such as binder rings and eyeglass hinges. Section 2 occupies the bulk of the new edition and is divided into general industrial products, specialized industrial products, hardware, and findings. These products cover almost every conceivable phase of industry, including a variety of unusual fastener types, gears and pinions, bushings, insulation components, and bearings, as well as a variety of specialized products for consumer use.

Source: Gries Reproducer Corporation
New Rochelle, N.Y.

For your copy: Circle No. 185 on Inquiry Card

Concentric Shaft Speed Reducer

The size of servo packages and other control assemblies is reduced by a new concentric shaft speed reducer. The single-ended plug-in type unit is built with its high speed input shaft coaxial with a low speed output sleeve. The input shaft extends about ⅝ of an inch to receive driving power. Great space and weight advantages as well as improved package reliability are achieved by use of these units.

Driving sources, potentiometers, cams, switches or other actuated devices as well as the speed reducer can all be mounted on the same base plate eliminating separate chassis, drive trains or other parts which add weight and take up valuable space. Reliability is improved because greater inherent rigidity is obtained with single mounting plate construction.

Equipped with an optional slip clutch to protect pot stops, the reducer has a backlash of 30 minutes maximum with a 3-inch-ounce reversing load. It is fabricated with passivated stainless steel bearing plates and gear clusters. Frame diameter is 1.062 inches and all types of mounting clamps, adapters and modifications are available to fill new application requirements. Bowmar Instrument Corporation, Fort Wayne, Indiana.

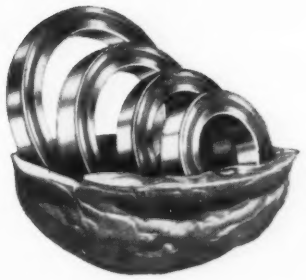
Circle No. 85 on Inquiry Card

WORTH FILING

Relay Catalog

A relay catalog, said to include the entire line of all major relay manufacturers, lists relays in alphabetical order according to code letters and numbers.

For copy of this catalog write:
Relay Sales, Box 186GL,
West Chicago, Illinois.



in a nutshell

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CIRCLE 12 ON INQUIRY CARD

AIR BEARINGS

Dynamic Forces That Contribute To Rotor Vibration

Gas bearing design has commonly been a matter of cut and try, in many cases resulting in discouragement and loss of money. Nevertheless, interest and investigation in this field have been increasing over the past years to the extent that the state of the art is approaching a complete technology. Five to ten years should put this field on a solid, thoroughly engineered footing, says Edward J. Garrett, Vice President of Analogue Controls, Inc., Mineola, New York.

Chief advantages of gas lubrication over any other type, he says, are low friction, good load-carrying capacity, excellent high-temperature properties, cleanliness, isolation to the working fluids of a system, infinite life, and excellent cold-temperature properties.

In general, Mr. Garrett says, the major barriers of journal bearing design have been lowered sufficiently to permit prediction of load-carrying capacity and high-speed operation within mechanical limitations. He reports that Analogue Controls, Inc. has developed experimental designs achieving speeds in excess of 160,000 rpm with trouble-free operation for 100 hours.

Some major considerations in bearing design were pointed out to us by Mr. Garrett. Two main considerations, he said, are: obtaining the desired speed and load carrying ability. Load carrying ability depends on the nature of the problem and available means. When hydrostatic pressure is available, load capacity is based on the simple formula, 1/3 pressure times area equals force to carry the load. With relative moving surfaces, a hydrodynamic load carrying film may be employed as in journal bearings. Another means of carrying a load is a squeeze film where relative movement is of a short duration in a transverse direction as in piston pin lubrication.

In applying these principles singly or in combination, phenomenon related to the flow of fluids must be considered. For example:

Clearance and orifice supply may cause a condition of "lock-up."

The built-in spring constant that determines load-carrying ability may cause shift in center of rotation to the c.g. instead of geometric center. If the unit is badly unbalanced, failure results. With large clearances, vibration at static bearing conditions may seriously impair a bearing. Selection of clearance must take into account possible dirt in the fluid. Particle size must be smaller than the minimum operating clearance. Usually large particles are filtered.

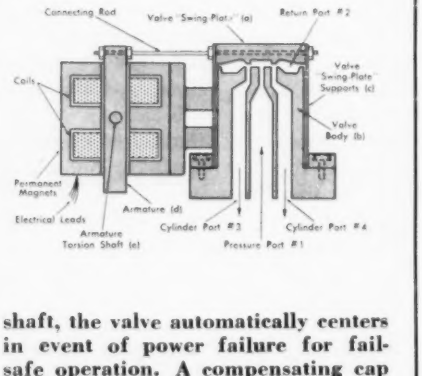
Power consumption resulting in a temperature rise of the lubricant must be considered in some applications. Since the fluid must shear, some heat is generated. Amount of heat depends on viscosity. Viscosity of oil is 100 to 1,000 times more than air. Power loss and temperature are of the same order of magnitude.

POSSIBLE CAUSE OF ROTOR VIBRATION

Possible causes of rotor vibration and instabilities have been and continue to be investigated by Analogue Controls in a research program on problems of high rotational speeds. They claim to have eliminated most of the causes. In addition to centrifugal forces arising from rotor unbalance, Mr. Garrett listed some sources of dynamic force contributing to rotor vibration that can now be controlled.

- DRY ROLLING. Because of imperfect lubrication, the shaft may climb the side of the bearing and centrifugal force keep it in contact to give a rolling action. This action causes high forces at a high frequency. Direction of rolling is opposite to the direction of rotor rotation. This problem is handled by choice of bearing materials and compounds.
- OIL WHIRLING. Vibration of rotors can be caused by oil film whirling around either at frequencies related to the critical frequency of the rotor or at a frequency slightly less than one half the rotor frequency. Oil whirling is practically understood in the present state of the art and can be controlled when necessary.
- FILM VIBRATION. A rigid rotor may bounce on the lubricating film because of transverse elasticity of the film. The problem here is one of clearances and volume in the bearing design.
- LAYER INSTABILITY. Instability may exist in the lubrication It may oscillate from hydrodynamic lubrication through boundary lubrication to imperfect lubrication, back through boundary to hydrodynamic lubrication. In this case, wear, damage or residue resulting from operation are the probable contributing factors.
- STRUCTURE VIBRATION. The

Sensitive Servocontrol Valve Has Only Two Moving Parts



Virtually eliminating sticking, scoring, and jamming, a single-stage electrohydraulic three and four-way servo valve developed by The Oilgear Company, Milwaukee, Wisconsin, contains only two moving parts: a torque motor armature and a swing-plate Since no metal-to-metal contact between swing-plate and valve body exists, the valve responds faster to minute signals. Clearances and port-seal sizes can be varied to suit application and fluid handled. Sharp, long, rectangular chambers and lands linearize valve characteristics and produce high fluid-power gain with minute swing-plate movement. Flow rate is essentially a linear function of valve displacement. Spring-steel, swing-plate supports respond instantly to low-torque motor forces. Because the torque motor armature pivots on a torsion shaft, the valve automatically centers in event of power failure for fail-safe operation. A compensating cap equalizes hydraulic forces to maintain selected clearances for operation above 500 psi. Hardened stainless-steel construction assures reliable operation well in excess of a hundred million cycles, even with non-lubricating fluids. Servocontrol open and closed-loop systems easily attain precision, high-response speed control from zero to maximum rpm in either direction through remote control stations or switches. Use of the system can also provide positive, high-response, follow-up, position control through remote-command units. Output motions or speeds with closed-loop systems will remain near constant with accuracies from 0.1% to 1.5%, and with resolution to 0.05%.

Circle No. 68 on Inquiry Card

rotor and its suspension system may be excited at their resonant frequencies. Structural vibration imposes a major stumbling block in the study of lubrication. Consideration must be given to the principal natural frequency, its multiples and the restraint.

• RESONANCE OF AIR DUCTS. Air lines and ducts leading to the nozzles may be excited at various frequencies. Duct resonance is easily confused with failures caused by lubrication or system instabilities.

• GYROSCOPIC EFFECTS. Any mode of vibration could be altered greatly by gyroscopic effects of the high-speed rotor.

• SUBHARMONIC RESONANCE. Vibration at a submultiple of the rotational frequency excited by periodic bearing-journal contact is a factor.

Various modes of bearing vibration, Garrett said, are affected differently by changes in test parameters; resultant changes may aid in identifying the mode of bearing vibration present.

Circle No. 35 on Inquiry Card

WORTH FILING

Low-Flow Servo Valves

6½-page brochure with detailed glossary of servo-valve terms contains a series of curves and schematics which highlight the design and performance characteristics of Moog's low-flow servo valves for military, industrial and research applications. Well-suited to situations requiring precise control at high-power levels such as flight control systems, nuclear reactor control devices, automatic machine tools, materials handling and process control equipment, more than 300 different models of valves in this series have been produced for specific application.

Source: Moog Valve Co. Inc.
East Aurora, N.Y.

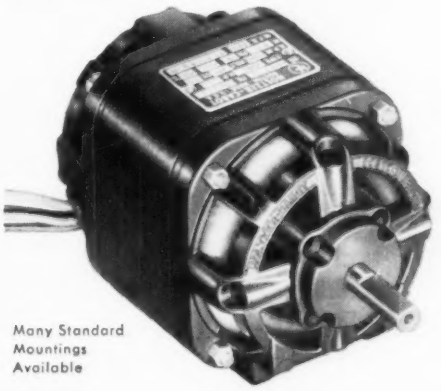
For your copy: Circle No. 203 on Inquiry Card

2-Way Packless Solenoid Valve

A new high-pressure 2-way packless solenoid valve controls air gases to 2500 psi and liquids to 1800 psi. Valve body and operating parts are of stainless steel, eliminating many corrosion problems. Packless construction is used throughout, eliminating stuffing boxes or sliding glands that require maintenance. With tight seating on both liquids and gases, without closely fitted parts the valve is suitable for low-temperature, high-pressure applications usually found in missile ground support and nuclear control systems, in addition to general purpose applications. Automatic Switch Co., Florham Park, New Jersey.

Circle No. 102 on Inquiry Card

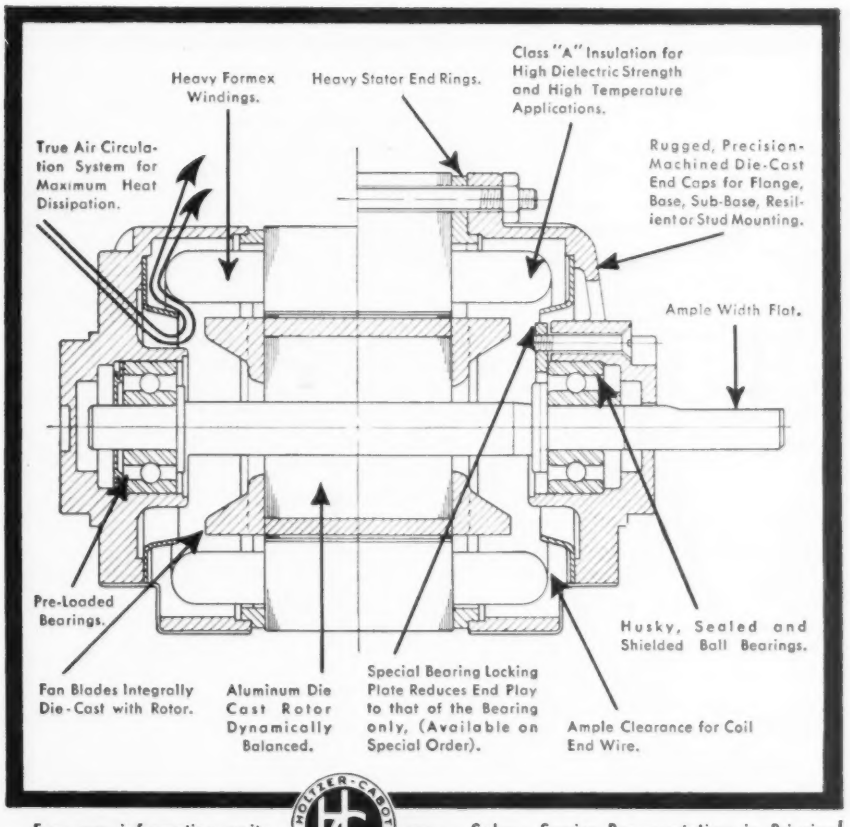
New Designs in Motors from HOLTZER-CABOT



Many Standard Mountings Available

TYPE R-29 MOTOR
2⅞" Diameter

This motor is an ideal power source for recording instruments, timers, medical instruments, office equipment, blowers, tape recorders, communications equipment, etc. It is available in both 2-pole and 4-pole design, each in three stacking lengths. Type R-29 is a permanent split capacitor type available as an induction or synchronous motor. H.P. of various models ranges from 1/75 to 1/30. Construction features are indicated below.


Heavy Formex Windings.
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Class "A" Insulation for High Dielectric Strength and High Temperature Applications.
True Air Circulation System for Maximum Heat Dissipation.
Rugged, Precision-Machined Die-Cast End Caps for Flange, Base, Sub-Base, Resilient or Stud Mounting.
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CIRCLE 13 ON INQUIRY CARD

Report from France

STAFF COLUMNIST

Emile Labin

Emile Labin is President of Automation-Electronique-Recherche Opérationelle in Paris, France.

ELECTROSTATIC GENERATORS

The first known type of electric generators were electrostatic. Until the end of the 19th century they played an important part in electrical research. However, since their operation and their basic limitations were not clearly understood, progress in the field of electrostatic generators was very slow. Until the second half of the 19th century, electrostatic generation of energy was based on the inefficient principle of friction. Power output did not exceed 10 watts for tremendous machines driven by vapor engines.

A fundamental step forward was taken by three German scientists, Topler, Holtz and Musacus who from 1865 to 1870 established the various forms of electrostatic induction machines with friction. The Holtz generator which had been used until the beginning of our century was remarkable; it could supply up to 10 w and 100 kv with a hand-driven, rotating disk of 40 to 50 cm.

Unfortunately, these achievements were due to intuition rather than scientific understanding and in the following years no improvements were made in spite of the best efforts of many inventors. They did not understand that power performances were determined by the intensity of the electric field in the air gap between stator and rotor and that this intensity was in turn limited by air ionization. Following a wrong analogy with electromagnetic machines they tried to improve performances by changing the nature of materials instead of surrounding gas.

Until the beginning of the 20th century numerous attempts made in this direction failed. Only one isolated scientist, W. Hempel, in 1886 installed an induction generator under a glass jar and varied the nature and pressure of the gas within the jar. He noticed that increased pressure was favorable and that carbonic gas was better than hydrogen. But his inability to understand the scientific basis of these tests made it impossible for him to appreciate their true value. Thus at the beginning of the century general opinion held electrostatic generators could not be improved and that for production of high voltages it was best to consider induction coils, or later, rectifiers. General interest in electrostatic generators dropped at the very time when the progress in physics made it possible to understand their behavior.

The development of nuclear physics requiring the use of very high voltages led to a come-back of electrostatic generators. In 1932 R. J. Van de Graaff thought of using the old induction principle in a new form, i.e. the belt type generator. Later the difficulties of operation in free air again led to the use of compressed gas. The technology of belt machines under pressure, developed at M.I.T. by J. G. Trump and later at High Voltage Engineering Corp., is now well established. These machines can give voltages up to 6 mv reliably with compact equipment, including in one housing under pressure both the generator and the accelerator tube using the energy produced.

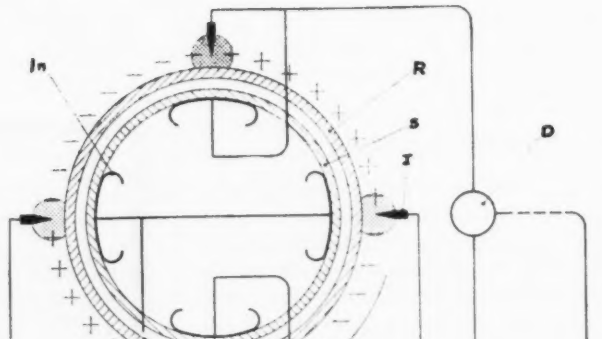

Fig 1—Schematic diagram of a cylinder generator.
E: driving generator
R: cylindrical dielectric rotor
S: slightly conductive stator
I: ionizer
In: inductor
D: output electrode
r: regulator
z:ionized region

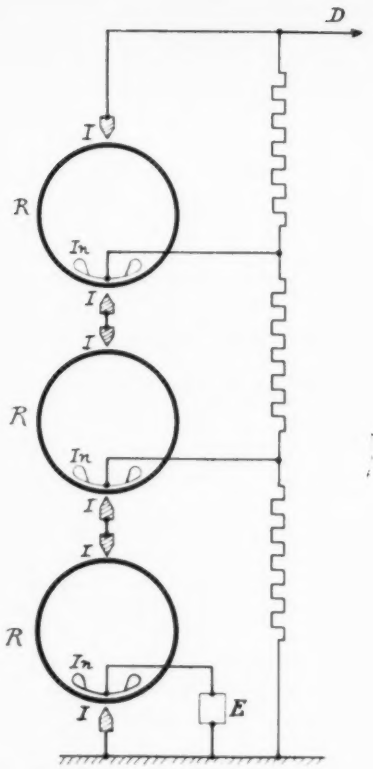

Fig. 2—Series coupling of 3 generators.

THEORY

The come-back of electrostatic generators due to R. J. Van de Graaff and J. G. Trump has been a challenge for further research. The Russians, Joffe and Hochberg, have tried to use rotating machines not only for nuclear physics and very high voltages, but also for ordinary voltages and even for d-c power long distance transmission. To make such applications possible it was necessary to reach large powers and more precisely large power densities per volume or per surface. It soon became obvious that a complete theoretical investigation was required. This was undertaken by Prof. Kossel from Tubingen in Germany and since 1942 by Prof. Neal and Felici of the "Labertoire d'Electrostatique du Centre National de la Recherche Scientifique" in Grenoble, France.

The most important information obtained in this field from the investigation is:

- The small power of electrostatic generators operating in air at normal pressure is due to the limitations of the electric field and the resulting ionization of the surrounding gas.
- Electrostatic forces depend upon the electric field squared just as magnetic forces depend upon the induction squared. If electric fields and magnetic induction are expressed respectively in ESU and EMU, intensities leading to the same forces are expressed by the same number. In normal atmosphere the electric field cannot exceed 30kv/cm or 100 esu while it is easy to reach 10,000 gauss before saturation or 100 times more, i.e. forces 10,000 times larger.
- Magnetic fields are therefore 10,000 times better than electric fields at normal atmosphere. This is why for similar dimensions electrostatic generators supply little power compared to electromagnetic machines.
- If pressure is increased, the maximum permissible field increases in proportion to at least minus 10 to 15 times normal atmospheric pressure. A perfect electrostatic machine should therefore supply a power 100 to 200 times larger by simple compression.
- It is impossible to achieve this improvement with

BOWMAR

PRECISION COUNTING DEVICES

MINIATURE LATITUDE COUNTER 2417

Latitude indications from 00°00′ North to 90°00′ North or South. Reversible, but not continuous rotation. Speed: 1500 rpm max. int., 500 rpm cont. Torque: .3 in-oz. @ 20° C. Wgt.: 1.5 oz.

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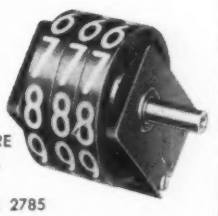

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Decimal indications from 000 to 999. Reversible and continuous rotation. Speed: 600 rpm max. int., 350 rpm cont. Torque: .5 in-oz. approx.@ 20°C. Wgt.: .75 oz.

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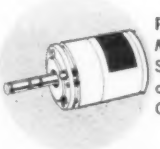

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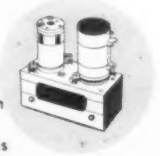

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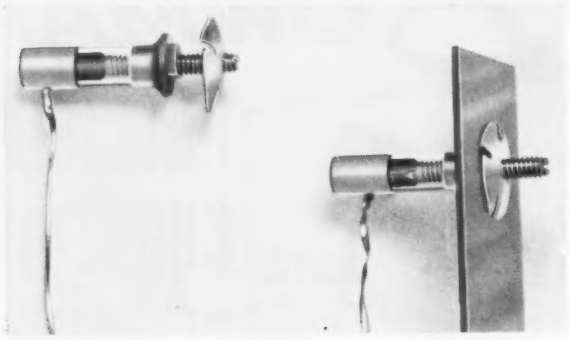
MINIATURE TRIMMING CAPACITOR



Illustrated same size — Patented

Designed for the coming space age, the ATLEE Variable Capacitor operates on new electro-mechanical principles to give a much greater range and higher stability with less space and weight than ever before.

Only $^{25}/_{32}$" long and $^{3}/_{16}$" in diameter, its capacitance range is 0.5 to 5.0 mmf. Has micrometer adjustment. Available in glass dielectric and brass for standard panel mounting or quartz and invar for special applications.

A rugged unit, it will maintain a set value under extreme vibration and shock *without undue stress!* Has excellent retrace characteristics. Full-floating piston assures positive mechanical alignment, eliminating run-out.

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CIRCLE 15 ON INQUIRY CARD

***New Miniature* POWER OUTLETS**
For Small Electrical and Electronic Units

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- TAKE STANDARD PLUG
- MOUNT FROM TOP OR BOTTOM OF FLAT BRACKET
- CHOICE PRE-WIRED STYLE, OR WITH SOLDERING TERMINALS
- PHENOLIC BLOCK HAS BARRIER TO PREVENT SHORTS
- AC and DC

SHOWN FULL SIZE

No. 221 (above) with soldering terminals and steel bracket with # 6 clearance mounting holes. Also No. 222 with 6-32 tapped mounting holes. No. 223 (left) with 8" #14 or #16 plastic wire leads and steel bracket with #6 clearance mounting holes. Also No. 224 with 6-32 tapped mounting holes.

WRITE FOR ILLUSTRATED BULLETIN.

KULKA ELECTRIC CORPORATION
Manufacturers of Electrical Wiring Devices
MOUNT VERNON, N. Y.
CIRCLE 16 ON INQUIRY CARD

SYSTEMS DESIGN

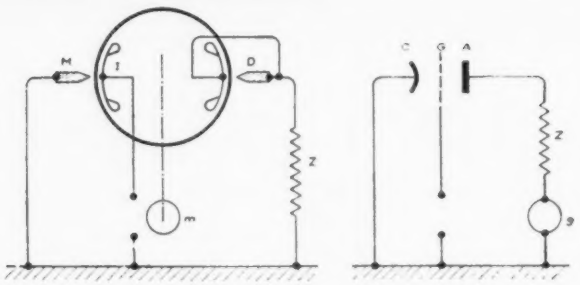


Fig. 3—Analogy between generator and triode.
M: ground ionizer
I: inductor
D: output ionizer
Z: load impedance
m: motor

any of the older designs. A careful study of the reasons for such failures has finally resulted in new generator designs in which full advantage is taken of increased gas pressure. Two major difficulties have been found with older designs: first, local field concentrations are much more dangerous under pressure; second, the required ionization at the brushes for machines where charges are being transported by isolated parts (discs, belts) is inhibited by pressure and the exchange of charges is difficult.

• In any case even by using a compressed gas as the dielectric it is no possible to reach power densities of the same level as in electromagnetic systems. When multiplied by 100 or 200, electrostatic forces will remain 100 times smaller than electromagnetic forces.

So far, the ambitious goal of power transmission has not been reached but the important progress achieved has permitted the electrostatic generators to enter the field of industrial applications and of medium high voltages (above 30 or 50 kv) instead of being confined to very high voltages and nuclear physics.

THE CYLINDRICAL GENERATOR

A French Company called S.A.M.E.S. 29, Avenue F. Vialet Grenoble (Isére), has developed a complete line of electrostatic generators with cylinders rotating in hydrogen under pressure. The cylindrical form has no special advantage for very high voltages but for large powers it is superior to other forms of moving parts such as belts because it may allow larger linear speeds without friction loss or damage.

The use of hydrogen which is a rather poor dielectric may seem surprising at first. It is, however, a great improvement over all other fluids (compressed air, carbonic gas, freon, etc.) Hydrogen will overcome the difficulty in operation under pressure of charging and discharging brushes because of the great mobility of its ions. As a matter of fact it is in a hydrogen atmosphere at 15 or 20 times normal pressure that the largest charge densities have been obtained. Hydrogen is the best compromise between requirements of large currents due to ion mobility, great efficiency due to small gas friction, long life due to lack of chemical harm by ionized hydrogen as compared to ozone or halogenes.

The general form of dielectric cylinder generators is represented in Fig. 1. The rotating dielectric cylinder is only a few millimeters thick. It is made out of insulating resin and is similar in function to the belt of the Van de Graff machine. This rotor rotates around a stator made out of slightly conductive glass (10^{12} to 10^{13} ohm-cm). The airgap is only 2 to 5 mm. Replacing the usual brush, very

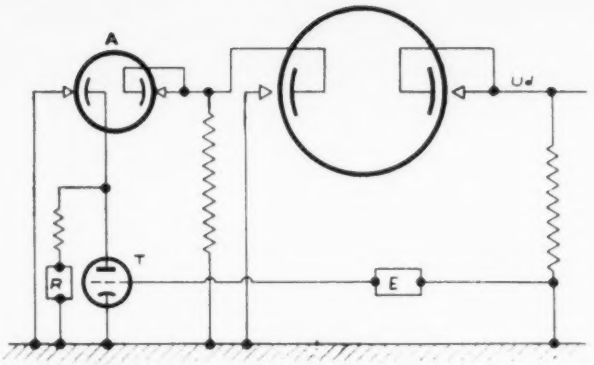


Fig. 4—Normal regulation for non-stabilized positive generator.
R: rectifier 75 kv, 200 MA
T: high gain triode
E:voltage reference
A: electrostatic voltage amplifier

thin steel strips charge and discharge the rotor as a result of induction of metallic inductors which are concealed by the glass cylinder.

This arrangement has given best results because the slight conductivity of the glass cylinder smoothes out the electric field in the gap, prevents sudden discharges and permits the field to reach maximum possible value. Actual electrical performances achieved are better than in any other machine: electrical charge density carried by the rotor is 60 esu normally and as much as 110 esu in laboratory tests. Average tangent field component from one ionizer to the next is 15 to 18 kv/cm (50 to 60 esu) and in one case reached up to 100 esu. Tangent force component on the rotor is therefore normally 3000 to 4000 dynes /cm^2 and may reach 6000.

Since linear speed on the rotor surface is normally 50 m/s, the power will exceed 1w/cm^2 in normal operation for a generator with a 20 cm diameter or more. Power of 1w/cm^2 is obtained by hydrogen at 15 to 20 atmospheres of pressure with an efficiency higher than 90%. This is an outstanding performance for an electrostatic generator considering that this power can be achieved in permanent operation without wear due to friction, or corrosion due to sparks.

The cylindrical arrangement also has the advantage of allowing the use of any even number of poles connected in parallel, thus making it possible to use currents as high as 10 or 20 ma. The output power is determined by the rotor surface and its speed does not change appreciably with the number of poles. With speed normally set at 3600 rpm, the output power is proportional to the volume or to the cube of the linear dimensions.

The following combinations have been obtained:

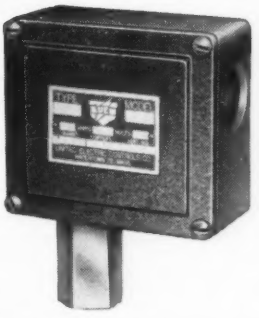
Rotor (diameter in mm)	No. of poles	Voltage kv	Current ma	Power kv
240	8	150	18	2.7
240	6	220	12	2.64
240	4	300	7	2.1
300	2	600	5	3.0

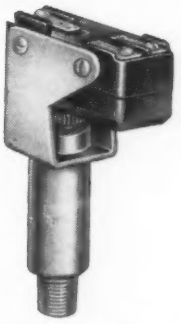
Other diameters are commercially available. A 70mm rotor will supply 90 kv and 0.2 ma; a 140 mm rotor machine will supply almost any combination between 300 kv and 1.2 ma to 80 kv and 5.0 ma. The cylinder type generator covers a large range of powers and voltages well suited to the needs of industry and laboratory.

At present the largest available voltage is 600 to 700 kv. However, a generator with a 500 mm rotor which will deliver 1.2 megavolts and 6 to 8 ma is under construction. After tests on this new design are completed, evidence

UNITED ELECTRIC
Multi-Purpose
PRESSURE CONTROLS J7 | J40

Enclosed-TYPE J7





Skeleton-TYPE J40

These controls are compact, precision-built, rugged and inexpensive. Type J7 is ideal for controlling air, gas or liquid pressures up to 500 psi . . . Type J40 for pressures up to 250 psi.

Adjustable Pressure Ranges	J7 . . . various models cover ranges between limits of 0 and 500 psi J40 . . . various models cover ranges between limits of 0 and 250 psi
Switch Ratings	15 amps or 20 amps at 115 or 230 volts A.C., also D.C. switches upon specification
Switch Types	N.C., N.O., or Double throw, no neutral position
Electrical Connections	J7 . . . screw type terminals on switch standard J40 . . . solder type terminals on switch standard
On-Off Switch Differential	Fixed and uniform throughout specified range is standard
Mounting	J7 . . . ¼" NPT female, brass fitting standard J40 . . . ⅛" NPT male, brass fitting standard
Variations	Design variations are available upon specification
Applications	On industrial equipment and engine applications . . . marine, aircraft or special purpose

Although UNITED ELECTRIC *offers a complete line of temperature, pressure and vacuum controls . . . UE application engineers specialize in solving unique problems.*

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91 SCHOOL STREET, WATERTOWN, MASS

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- Reduced cost
- Long life
- Friction reduction
- Corrosion resistance
- Dry operation
- Non-magnetic material

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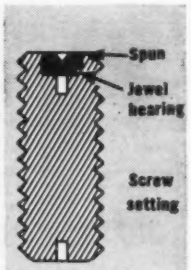
Bird Complete Jewel Assemblies

. . . save time and money, cut rejects, keep production flowing smoothly. Special mounting techniques provide assemblies in screws or bushings of any style.



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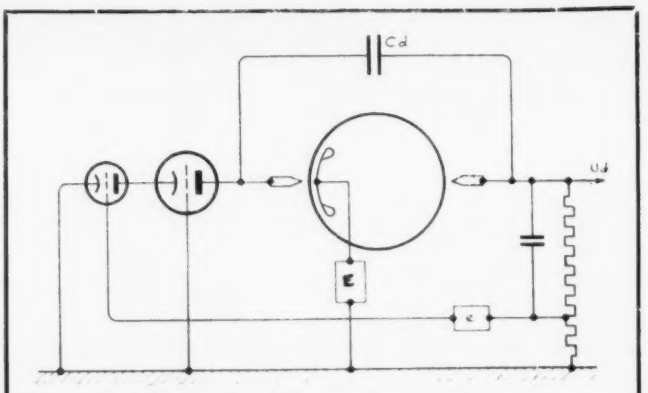


Fig. 5—Regulation of stabilized negative generator.
E: fixed drive
e: voltage reference

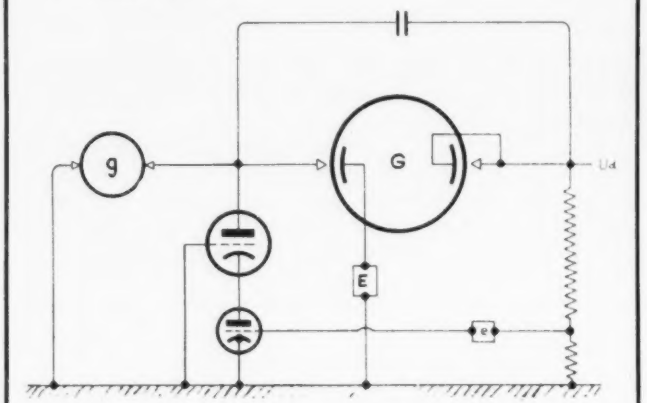


Fig. 5a—Regulation of stabilized positive generator.
g: auxiliary large current generator

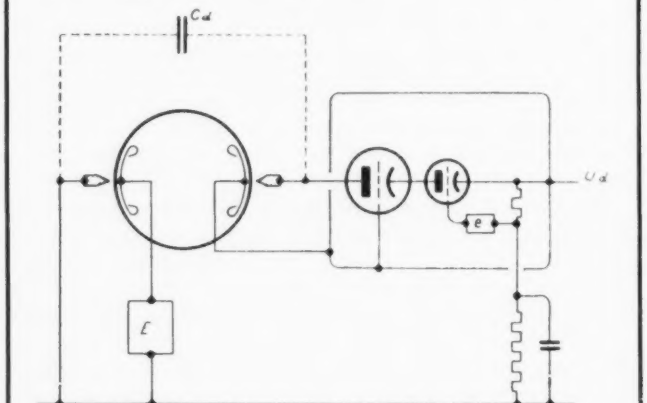


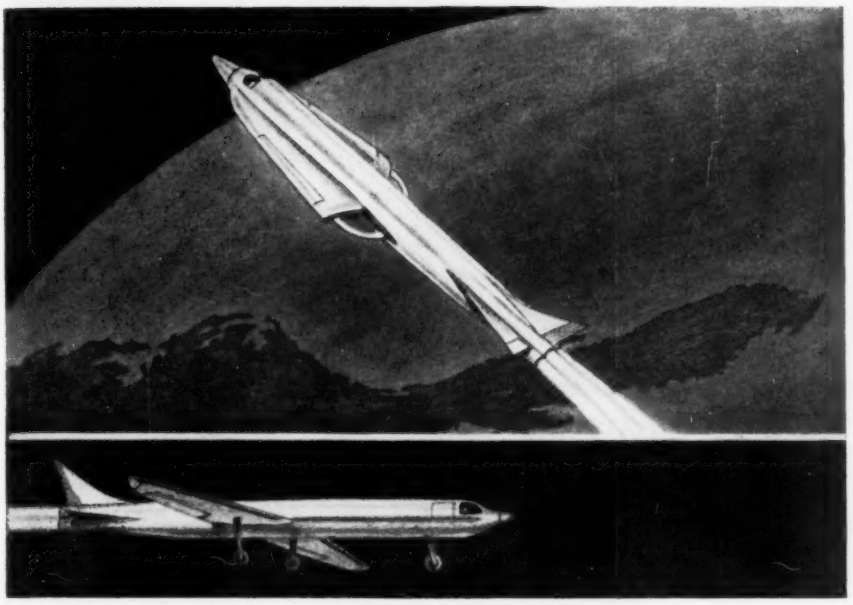
Fig. 5b—Output regulation. Outside condenser Cd is not necessary.

will indicate whether the cylindrical type is adaptable to the megavolt range. To reach higher voltages it is possible to connect several generators in series. Such systems have not been used industrially but laboratory tests have obtained 1600 kv with three 600 kv generators in tandem, limited only by insulating difficulties in free air. Coupling conditions for stable tandem operations have been determined and are illustrated in Fig. 2.

REGULATION

The cylinder type generator even more than the belt type is easy to regulate electronically. It is unfortunate that many engineers do not seem to be familiar with the remarkable properties of electrostatic generators. These properties can easily be understood through analogy between a generator and a grid controlled triode as shown in Fig. 3. The current of one electrostatic generator is

MARS outstanding design **SERIES**



brings 'em back alive

Today's burning problem in space flight is how to ease a rocket safely back to earth, without being consumed by the metal-melting friction of our dense atmosphere. Design Engineer Carl J. Rauschenberger's ingenious suggestion is a pair of wings, locked forward at blast-off, later folded back into flying position (insert) by hydraulic cylinder controls for a slow, safe descent. Mr. Rauschenberger also envisions a retractable glass nose cone, heatproof to withstand the take-off, drawn back to admit air to a jet engine on the return flight.

This outstanding solution to a timely design problem may already exist in working drawings on somebody's drafting board, or even in mock-up form. But whether a project is developed today, tomorrow or the year after next, it will always be important to shape ideas into realities with the best of drafting tools.

In pencils, of course, that means Mars, long the standard of professionals. Some outstanding new products have recently been added to the famous line of Mars-Technico push-button holders and leads, Lumograph pencils, and Tradition-Aquarell painting pencils. These include the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman" pencil sharpener with the adjustable point-length feature; Mars Lumochrom, the color-drafting pencils and leads that make color-coding possible; the new Mars Non-Print pencils and leads that "drop out" your notes and sketches when drawings are reproduced.

The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom color-drafting pencil, 24 colors.

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3rd MARS Design Contest

HACKENSACK, N. J. — The MARS Outstanding Design Contests have uncovered numerous interesting designs which might otherwise never have been brought before technical audiences. They have attracted such wide interest that MARS Pencils is sponsoring another contest in 1959.

Carl J. Rauschenberger, Anaheim, Calif., one of the winners in the 1958 MARS Contest. Mr. Rauschenberger's project, "Brings 'em Back Alive," is featured in the MARS presentaiton on this page.

If you are an engineer, architect or student, the MARS contest offers you a "showcase." It provides you with a valuable opportunity to have projects you designed shown in leading magazines where they will be seen by the men in your profession.

$100 Awards

Send in your designs. Every winner will receive $100; winning entries will be reproduced in the wide list of technical publications in which the MARS Outstanding Design Series appears. There are no strings attached. You will be given full credit. All future rights to the design remain with you. You can reproduce it later wherever you like and sell or dispose of it as you wish.

The subject can be almost anything — aviation, space travel, autos, trains, buildings, engineering structures, household items, tools, machines, business equipment, etc. Projects will be selected on the basis of appeal to design-minded readers, broad interest, attractive presentation. Do not submit a design that is in production. The project, in fact, does not need to have been planned for actual execution. It should, however, be either feasible at present or a logical extension of current trends. It cannot be unrealistic or involve purely hypothetical alterations of natural laws.

The sooner you send in your entry, the greater the chance of its selection.

It is Simple To Submit a Design For Mars Outstanding Design Series

Just mail in an inexpensive photostat or photocopy of the subject — one you can spare, since it cannot be returned — and a brief description.

If your entry is accepted, we will ask for a clear illustration of your design in order to prepare a sharp rendering, or photograph suitable for reproduction. Your material will then be returned to you.

Send your entry to:

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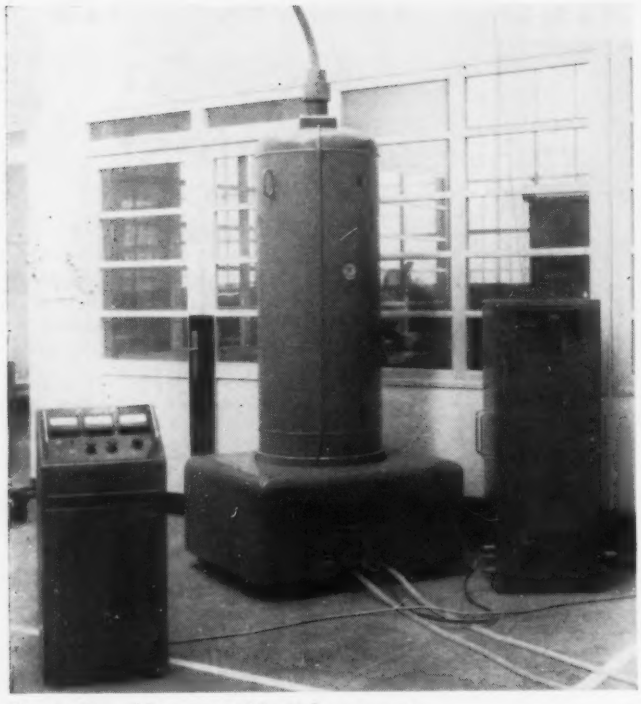

Fig. 6—Portable very stable 50 kv generator.

determined by the driving voltage just as plate current in a triode is determined by grid voltage. Driving power is very small as in a triode.

Some available high voltage triodes (such as the 6BD4A) seem to be made for regulating electrostatic generators (30 kv). Depending upon the application desired, various regulators that will insure voltage stabilities and regulation with load from 1% down to .01% are available. One commercial portable type generator to be used for insulation testing will supply voltages from 1 to 100 kv with voltage fluctuations less than 0.1v

For normal regulation the amplifier tube will act on the generator drive through an additional auxiliary generator used as a voltage amplifier (See Fig. 4). In such a loop transmission delays cannot be neglected. The generator, itself, rotating at 3600 rpm with 2 poles will introduce a delay of 1/120 second. The additional auxiliary generator could add another 1/120 second; other circuits may finally build up the total delay to 1/50 of second. This means that the servo loop should not operate above 25 cps. In this simple arrangement only low frequency variations can be smoothed out by the servo-control.

To achieve better stability and control high frequency perturbations, the main source of delay must be eliminated. The main generator can be by-passed by a condenser which can be very small and the auxiliary generator can be by-passed by a large gain amplifier as shown in the configuration of Fig. 5. Notice the important advantage of the fast-rotating cylinder-type system as compared to the belt system from this point of view.

SAFETY

I would like to add a few remarks on the major advantage of electrostatic generators: safety of operation, safety for the human operator as well as for the equipment supplied by the generator. Electrostatic generators are perfectly harmless even at powers of several kw. The only effect is due to the sudden discharge of the generator's own self capacity. This capacity is normally very small, even for highly stabilized machines.

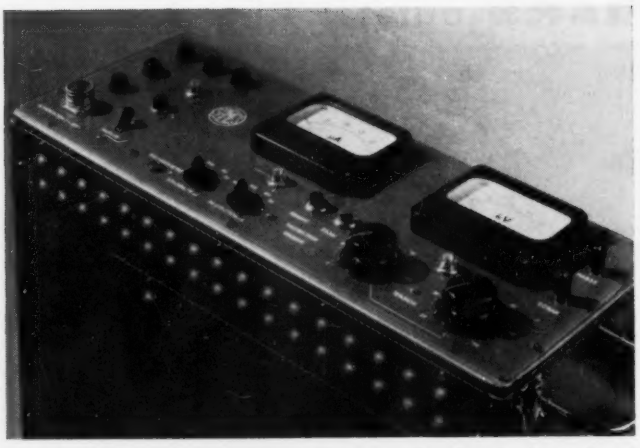

Fig. 7—600 kv, 5 mA generator. Pressure chamber in the pedestal and electronic gears in the cabinet.

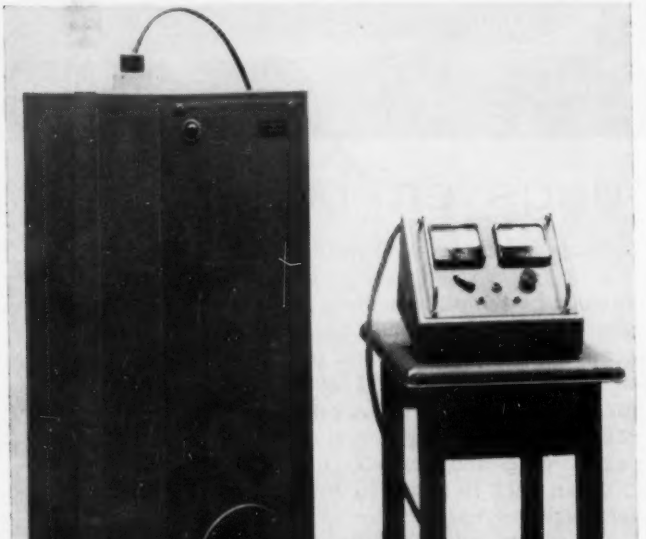

Fig. 8—100 kv, 3 mA generator.

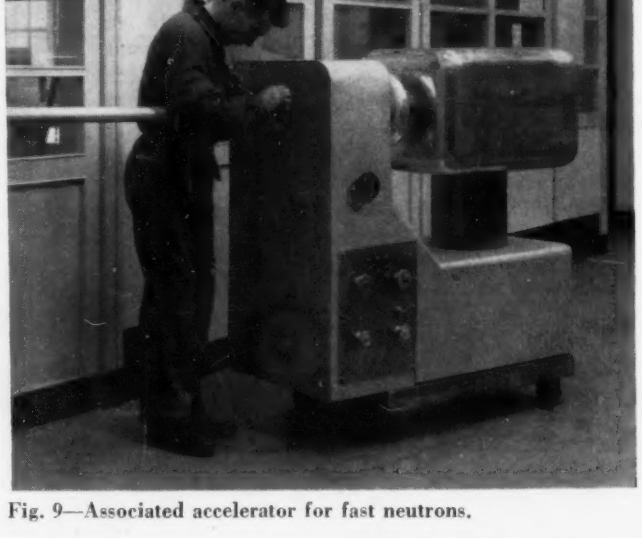

Fig. 9—Associated accelerator for fast neutrons.

With rectifier type generators current flows through the human body. With an electrostatic generator the largest current that can be supplied never exceeds 20 to 30% of its nominal value. As soon as this value is reached the voltage immediately drops to zero. A 10ma generator never supplies more than 12 to 14 ma while the short-circuit current of a transformer can be as large as ten times its nominal value.

Prof. Charles F. Dalzied of the University of California has measured the physiological effects of d-c current and has found the following results:

0.6 ma:	no effect
3.5 ma:	slight perception
6 ma:	commotion not unpleasant
50 ma:	unpleasant commotion but one cannot drop the conductor
60 ma:	breathing difficulties
500 ma:	danger of death

An X ray electrostatic generator designed for a normal current of 20 ma will never supply more than 25 ma even for a short-circuit due to contact by the patient. This is an important advantage of well designed electrostatic generators.

CONCLUSIONS

Electrostatic generators have not yet solved the basic problems of high power d-c transmissions and do not seem likely to solve them in the near future, but electrostatic generators have made great progress and are now useful tools for many applications. Electrostatic cylindrical-type generators are economical for voltages above 20 or 30 kv when extreme voltage stability is required, for voltages above 50 kv, when good stability is required, and for voltages above 100 kv where stabilities of 1.0% are sufficient. Cylinder type generators do not seem to be very interesting at less than 10 or 20w because they require some auxiliary driving equipment.

The present range of powers extends from 20 to 3000 w. It is likely that this range will be expanded in the near future to 6 or even 10 kw. Although these powers are modest indeed in comparison with powers supplied by large alternators, electrostatic generators are satisfactory for most high voltage applications and have the advantage of extreme safety, of excellent regulation and stability, and of very small size.

Electronic Commutator

New solid-state high-speed electronic commutator will commutate up to a maximum of 1000 channels of information at rates of up to 100,000 samples per second, and can be used with any device requiring this type of commutation. It may be used to commutate either a-c or d-c signals to a voltage-to-digital converter or may be used to commutate the output of a digital-to-voltage converter into a number of channels. If a holding circuit is required for the voltage outputs, solid-state sample and hold circuits are available.

Used with the Packard-Bell Multiverter, a solid state, high speed conversion system, both a 24-channel multiplexer and the voltage-to-digital converter can be fitted into 5¼ inches of a standard 19-inch relay rack.

The accuracy of the switches is a function of the full scale of the voltages being commutated. For example, a full scale of ±1 volt would have a total error of .07 percent; a full scale of ±8 volts would have a total error of .027 percent.

Because of the small size and power requirements, systems of this type are well suited to airborne applications. Packard-Bell Electronics Corp., Los Angeles, California.

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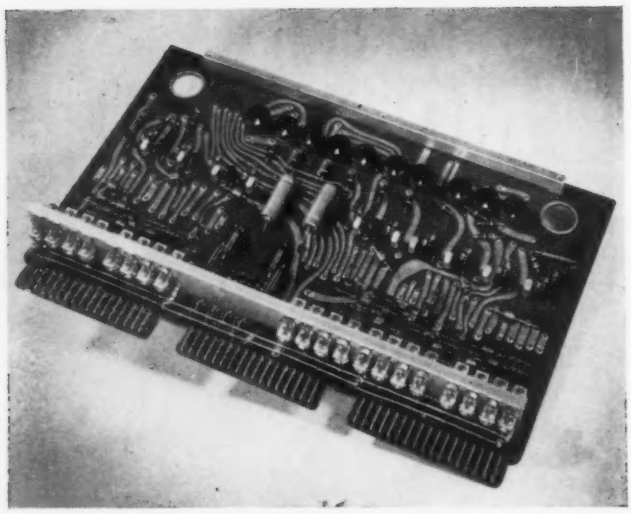


Address decoding is accomplished by use of magnetic cores; 10 are mounted at rear of this typical plug-in unit. On the same board, selection line drivers mount on a common heat sink.

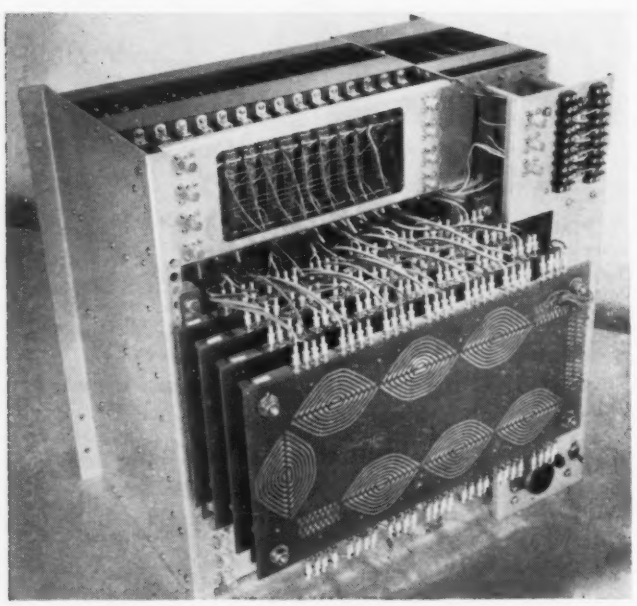
MAGNETIC CORE STORAGE SYSTEM

Low Cost Core Memory for Random Access

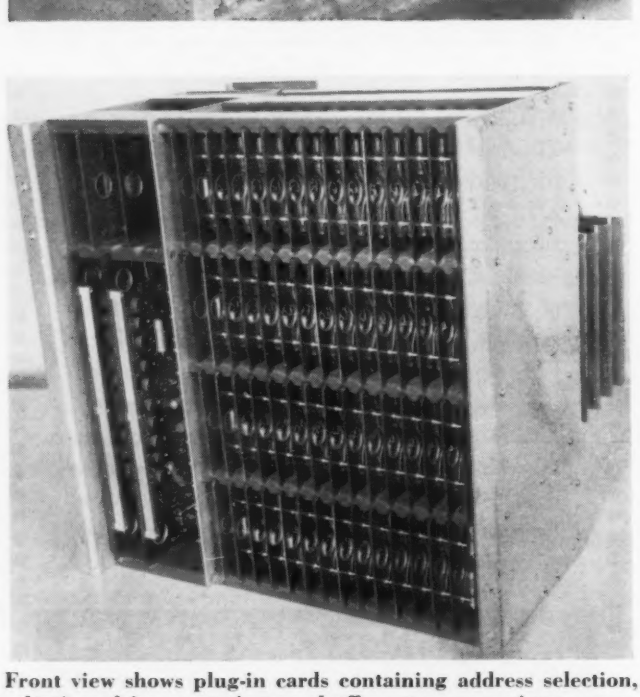
Designed by DI-AN Controls Inc., Boston, Mass., for use in small computers and special-purpose data-handling equipment, a coincident-current magnetic core storage system has 5200 memory storage bits with random access and serial input and output. Standard memory building blocks make up memories that can: accommodate as many as 512 words as long as 60 bits each; handle two megacycle bit rates; utilize any combination of serial and parallel inputs and outputs; dispense information in 6 microseconds. Address information input for the transistor operated system can be pure binary, binary-coded decimal, hexadecimal, etc. Extensive use of magnetic cores in the logic, decoding, and drive circuits of these systems reduces the transistor and diode count, improving reliability.

Typical applications for these storages include: use as buffers to high-speed printers, buffers in code translators and between tapes, drums, punches, and other asynchronous equipments; use in main computer memories, digital correlators, multi-channel radiation analyzers, and high-speed data acquisition systems.

Circle No. 71 on Inquiry Card



Rear view of coincident-current magnetic-core storage system shows the four storage boards which contain 12,500 memory cores, address 1 line inputs in the upper right hand corner and power connection in the lower right hand corner. Plug-in connections to the memory boards provide flexibility of application. Information inputs, control and operation command inputs feed through coax fittings.



Front view shows plug-in cards containing address selection, selection drivers, static-type buffer storage register, sense amplifiers, and memory-cycle control circuits.

Use of basic circuit plug-in modules permits variation in the use of assembly storage systems to meet the word-length and total-word requirements of different systems.

Portable Transistorized Power Supply

An all-transistor power supply, designed to provide external 12-volt d-c power for portable, battery-powered test instruments, permits use of electric power and the saving of batteries for locations where line power is not available. Regulated to provide a stable d-c source comparable to the output of a battery, the unit can handle four instruments simultaneously without interaction caused by common power-supply impedance. Four outputs on the panel are individually filtered and the power supply proper has an additional filter. Ripple is low—less than 200 microvolts—and the d-c source impedance is less than that of a battery. Using printed circuitry and miniature components, the 6 x 8 x 6¼-inch instrument weighs 5½ pounds. Alectra Division, Consolidated Electrodynamics Corporation, Pasadena, California.

Circle No. 106 on Inquiry Card

Welding Power Supply

Controlled output from 2 to 500 watt-seconds is now available in a new resistance welding power supply engineered for heavy-duty applications. Uniform and reliable welds can be made on difficult metals and large assemblies without water cooling. Deformation and discoloration are minimized, and there is no electrode burn-off or operator shock hazard. Weldmatic Div. of Unitek Corp., Pasadena, Cal.

Circle No. 191 on Inquiry Card

WORTH FILING

Synchro Testing Methods

14-page technical bulletin describes synchro test methods in detail and emphasizes the application of the synchro and resolver bridge for component and system measurements. Application factors treated include: loading, voltage, and frequency characteristics; quadrature rejection, measurement intervals; instrumentation to detect the bridge output; origin of error curve.

Source: Theta Instrument Corp.
East Paterson, New Jersey

For more information: Circle No. 127

WORTH FILING

Microwave and UHF Test Equipment

84-page catalog describes the complete Narda line, including new millimeter waveguide instruments for the K-to-E band, standard-gain horns for the 40,000 to 90,000 mc range, broad-band bolometers and thermistors, tunable waveguide detectors, high-directivity directional couplers, coaxial hybrids, tuned pre-amplifiers and transistorized VSWR amplifiers, and laboratory and classroom training sets. Newcomers to the field may find helpful the illustrations of typical component set-ups for the measurement of impedance, attenuation, and other properties of waveguide and coaxial systems.

Source: The Narda Microwave Corp.
Mineola, N.Y.

For your copy: Circle No. 206 on Inquiry Card

WORTH FILING

Screw Thread Metrology

16-page illustrated handbook reviews the function and facilities of each of three new Screw Thread Metrology (Measurement) Laboratories and shows the various precision equipment needed for properly checking unified screw threads (Classes 3A, 2A, 3B and 2B), tapered pressure plugs (ANPT and NPTF) and special precision thread forms. A seven-page appendix of reference material extracts pertinent data on screw thread dimensions and tolerances from the recently revised H-28 Handbook.

Source: Standard Pressed Steel Co.
Jenkintown, Pa.

For your copy: Circle No. 126 on Inquiry Card

WORTH FILING

Miniature Solderless Connectors

10-page brochure outlines insert arrangements, test voltages, amperage ratings, physical dimensions, and pin patterns for 2 classes of miniature, crimp-type, solderless connectors of the KM series: class E (environment resisting) and class H (hermetically sealed mating receptacles to class E). Series includes basic endbell styles: short, straight, 45 and 90.

Source: Cannon Electric Co.
Los Angeles, California

For your copy: Circle No. 123 on Inquiry Card

Electronic Clock Errors

Brochure contains graphs for computing cumulative errors in electronic clocks; discusses theory; gives two examples on the use of the graphs and describes timing equipment.

Source: Hycon Eastern Inc.
Cambridge, Mass.

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ELECTRICAL ENGINEER'S GUIDE TO INSULATED wire

subject: APPLIANCE WIRE

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LIGHTNING ARRESTER DESIGN

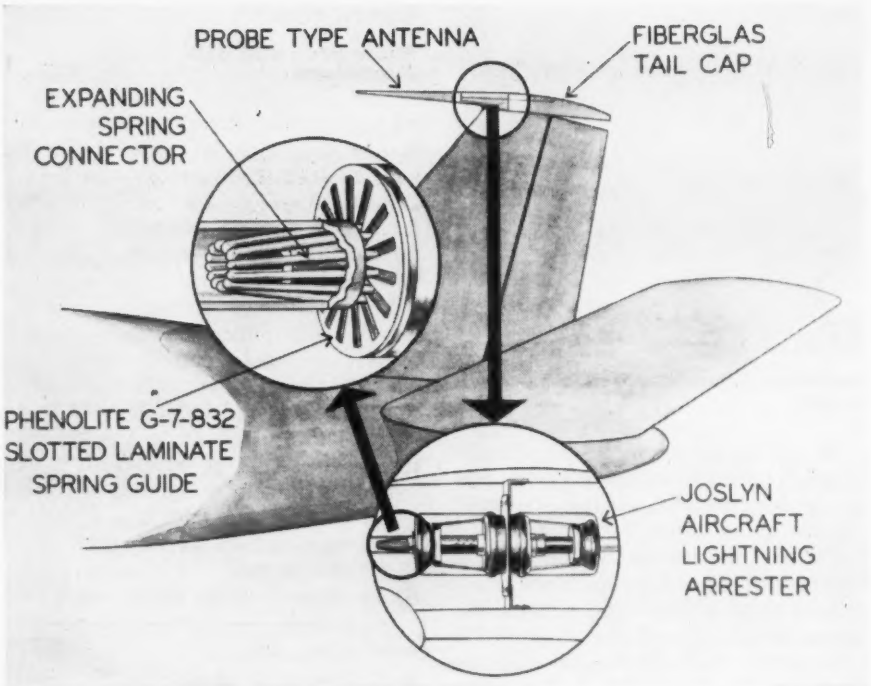
Slotted Laminate Guides Lightning Arrester Spring Movement

An unusual expanding spring connector fastens a lightning arrester to latest probe-type aircraft antennas. Developed by Joslyn Mfg. and Supply Company, Chicago, Illinois, the arrester employs 15 phosphor bronze spring elements which provide a slide-in, press-fit assembly and positive electrical connection with the plane's tubular aluminum radio antenna.

Key to the success of this design was the selection of the proper material to serve as a spring guide. This involved both electrical and mechanical considerations since the part must act as an insulator as well as a guide.

Chosen for this application was Phenolite G-7-832, a silicone glass-fabric laminate made by National Vulcanized Fibre Co. of Wilmington, Delaware. Combining good electrical and mechanical qualities, G-7-832 has high physical strength, good electrical characteristics and superior punchability. This material also withstands severe vibration without fatigue or breakdown and is resistant to fungus growth.

Punched from 0.0625 inch stock, the 1.75 inch diameter silicone Phenolite spring guides have 15 slots to accommodate the spring elements. Assembled into the top brass piece, the laminate disc rests on a shoulder and is staked into permanent position. Once the spring elements are assembled their ends can be moved in and out on a guided, insulated path in the slots with no danger of touching any other metal surface.

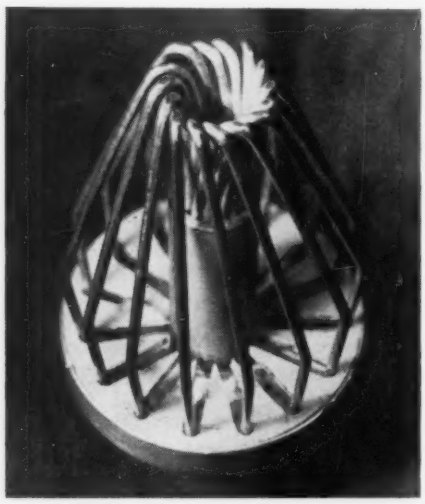


Schematic drawing shows how lightning arrester connects to probe-type radio antenna in jet aircraft tail section. Spring-type fastener provides press fit assembly with tubular aluminum antenna. Phenolite G-7-832 slotted laminate spring guide acts as both an electrical insulator and a mechanical guide for the 15 phosphor bronze spring elements.

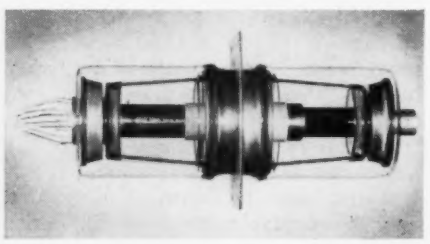
Lightning current from struck antennas flows through a preferred path to the structure of the aircraft, preventing it from entering and damaging interior circuits. To accomplish this, the arrester employs protective gaps in a hermetically sealed chamber equipped with a ceramic capacitor which permits the flow of radio energy between the antenna and the transmitter and at the same time acts as a barrier to lightning discharges.

Designed to operate at altitudes up to 50,000 feet and at temperatures ranging from −80F to +160F, the 7 pound, 3 ounce arrester safely discharges lightning strokes having peak currents as high as 100,000 amperes and 200 coulombs charge.

Circle No. 69 for more information on G-7-832
Circle No. 65 for more information on Arrester



Close-up view of the expansion spring fastener shows how the slots in the Phenolite part guide the movement of the 15 spring elements while insulating them from other metal surfaces.

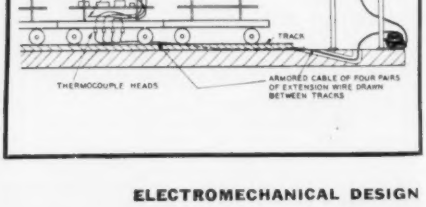


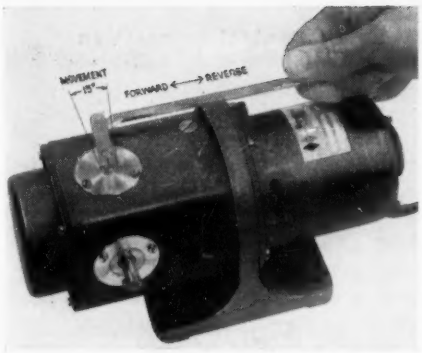
An expanding spring connector fastens this aircraft lightning arrester to tubular aluminum radio antennas

Traveling Tunnel Kiln Pyrometer System

A new traveling tunnel kiln pyrometer records the temperatures to which work passing through a kiln is subjected. This continuous record makes possible accurate adjustments to kiln controls based on actual working temperatures. Mounted on a test car in the required locations, swaged thermocouples of specified length connect to a Bristol Dynamaster Potentiometer by a long, armored, extension cable containing a pair of extension wires for each thermocouple. The cable is fed from the recorder into the kiln and drawn through the kiln with the test car. Users have reported that one trip through the kiln saves them more than the cost of the thermocouples. The Bristol Co., Waterbury, Conn.

Circle No. 250 on Inquiry Card



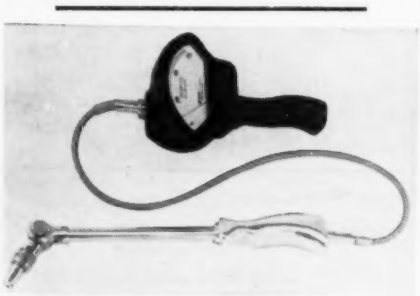


Variable Speed Drive

A new mechanical variable-speed drive for up to ¼ hp, Servotran, makes an ideal integrator for computers and weighing systems. With constant output torque, efficiency between 85% and 95% and infinitely variable speed, Humphrey's new drive comes with a solenoid-operated instant electric shift or with a calibrated dial for manual adjustment.

For automatic control applications, a lever and push rod speed control is available; speed control shaft moves through an arc of only 15 degrees to shift from full-speed-forward to full-speed-backward in less than 1/10 second without disengaging the load. Only two or three inch ounces on the control shaft shifts the Servotran. This ease of speed control makes the drive ideal for automatic control applications because very slight control forces fed back from the system provide all necessary control without requiring amplification. Humphrey Products Division, San Diego, Cal.

Circle No. 246 on Inquiry Card



Portable Hand Pyrometer

A simple method of measuring temperatures of various materials and surfaces with West's portable hand pyrometer requires no power source, special tools or operator skill. It may be used for measuring temperatures of convex, rotating or flat surfaces; for plastics, rubber or semi-fluids, liquids, gases or molten soft metals. The pyrometer has 12 scale ranges automatically compensated for changes in ambient temperature. West Instrument Corp., Chicago, Illinois.

Circle No. 211 on Inquiry Card

WORTH FILING

Self-Sealing Coupling

Bulletin covers Aeroquip's new self-sealing coupling. Designed, in accordance with MIL-C-25427, for 3000 p.s.i. aircraft hydraulic systems, it prevents dangerous partial connections. Design and construction are fully explained with illustrated principles of operation. Other information includes complete dimensional data, list of accessories and installation instructions.

Source: Aeroquip Corporation
Jackson, Mich.

For your copy: Circle No. 214 on Inquiry Card

WORTH FILING

Ebullient Cooling Medium

28-page booklet compares conventional and ebullient cooling, and discusses the properties of Dowtherm 209, a new boiling heat-transfer medium. The development and advantages of the medium are discussed briefly together with its corrosion and thermal stability properties and determination of concentration. 11 graphs illustrate quantitatively its physical and chemical characteristics.

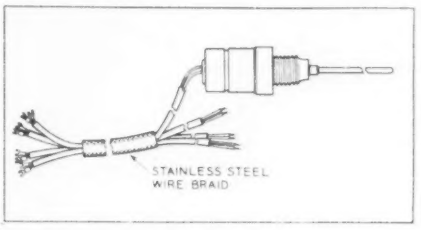
Source: Dow Chemical Co.
Midland, Michigan

For your copy: Circle No. 125 on Inquiry Card

Special Purpose Thermocouple

Metal-sheathed, ceramic-insulated thermocouple measures temperatures up to 2000F at pressures up to 50,000 psi. Easily bent twice around its own diameter to get into out-of-the-way places, the thermocouples are available in chromel-alumel, iron-constantum, copper-constantum and other materials and supplant conventional pencil-type thermocouples. The Bristol Co., Waterbury 20, Conn.

Circle No. 249 on Inquiry Card



WORTH FILING

Phase Dividing System

6-page engineering bulletin, complete with graphs and schematics, discusses the comparison between sine-cosine and linear potentiometer methods of phase dividing.

Source: Technology Instrument Corp.
North Hollywood, Calif.

For your copy: Circle No. 204 on Inquiry Card

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Specialists in the Unusual
To fill a need for high temperature insulation in a high conductivity wire. Precision drawn to close resistance control in the smaller sizes.
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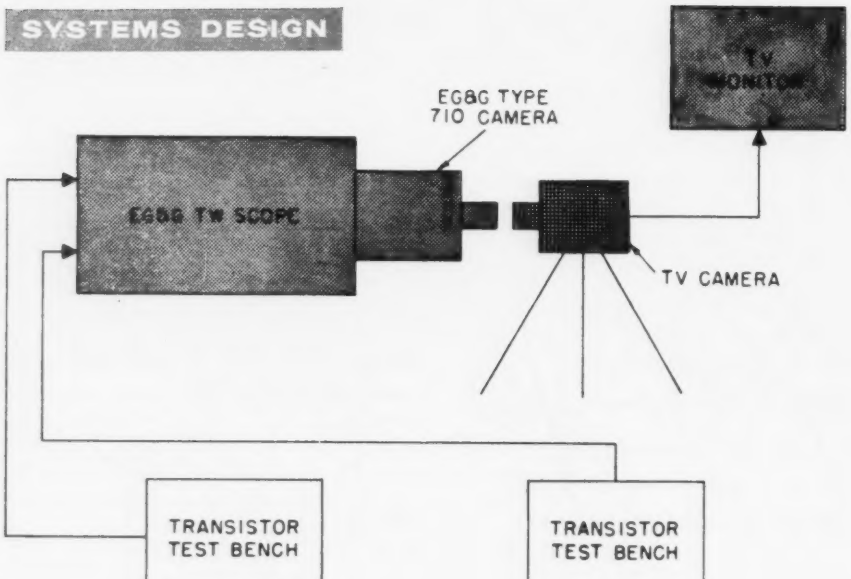
CIRCLE 22 ON INQUIRY CARD



Block Diagram of traveling wave oscilloscope television inspection system

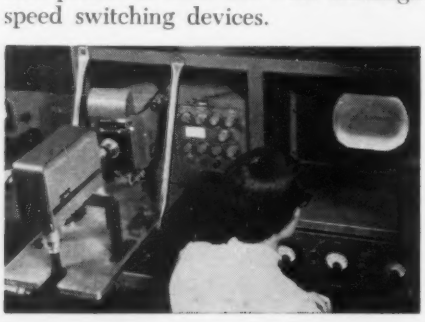
TW SCOPE-TV INSPECTION SYSTEM

Traveling Wave Scope Solves Inspection Problem

Accurate display of transient and repetitive waveforms in the millimicrosecond region makes the Edgerton, Germeshausen, and Grier traveling wave oscilloscope an old friend to research teams.

Lansdale Tube Co. found a new application for this scope in their production line inspection department. They are manufacturing a new ultrahigh speed switching transistor with rise times on the order of one millimicroseconds and switching potentials of about 10 volts.

In the usual solid deflection plate type of cathode-ray tube a 10-volt potential is too low to deflect the beam without first amplifying the signal, and the long rise time of available amplifiers precludes their use with ultrahigh speed switching devices.



Operator checks transistor waveforms on television screen as part of production line inspection.

The traveling wave scope solved the problem because it is capable of producing full scale deflection with a 10-volt input, and its rise time of 0.1 millimicrosecond ensures that the observed rise times originate in the transistors and not in the test instrument itself.

Lansdale has developed a closed circuit TV system (block diagram) to display the transistor waveforms on a 17-inch television screen. The transistors are connected to the TW Scope's deflection system. Mounted over the oscilloscope's screen is a camera with a 5X magnifying glass for visual observation of the screen. The TV camera is focused on the screen through this magnifying glass, and the transistor waveforms are displayed on the TV monitor. To establish a time scale, they inserted an edge-lighted reticle into the camera at the film plane.

Lansdale improved the system to serve two transistor test benches with a single TW scope-TV setup. The TW scope has a push-pull deflection structure. Ordinarily both sides are fed simultaneously in opposite polarity, but Lansdale connected each side to a separate transistor test bench. Thus, while one operator reads the rise time of a transistor under test, the second operator prepares the next transistor for insertion into the test setup. By so connecting the transistors to the TW scope, the waveforms are displayed in opposite directions. This does not affect either the accuracy or ease in reading the waveforms, but has an added advantage of eliminating any confusion as to which operator is feeding the signal to the TW scope.

Circle No. 40 on Inquiry Card

WORTH FILING

Materials Control Automation

8-page two-color bulletin contains photographs, operational data and design-feature descriptions of twelve varied products for positive control of materials in motion. Items described are: dal flow tube for metering water, gases, slurries, and corrosive fluids; venturi tubes for main-line metering; venturi flow nozzle for high-pressure fluid metering; venturi insert nozzles; chronoflo telemeters for remote metering and control of distant process variables and equipment; transistorized Synchro-Scan Systems for multi-function central supervisory control industrial processes; rubber-seated butterfly valves; Pneumatic Valve Positioners, Shuntflo Meters; propeloflo velocity-type totalizing liquid-flow meters; conveyoflo meter for automatically and continuously weighing and totalizing belt-conveyed dry materials; and visible flow chlorinizers.

Source: B-I-F Industries, Inc., Providence, R. I.

For your copy: Circle No. 194 on Inquiry Card

High-Strength Fasteners

A new series of high-strength, double-hex, external-wrenching, self-locking nuts consistently develops the full fatigue-strength of 220,000 psi bolts. Cold formed from alloy steel and cadmium plated with a supplementary molybdenum disulphide dry-film lubricant, the nuts are usable in airframes and missiles designed to withstand severe supersonic flight stresses and related vibrations. Moreover, they are 10% to 33% lighter than the lightest 180,000 psi locknuts presently available in thread sizes ¼-28, 5/16-24, ⅜-24, 7/16-20 and ½-20. Elastic Stop Nut Corp., Union, New Jersey.

Circle No. 104 on Inquiry Card

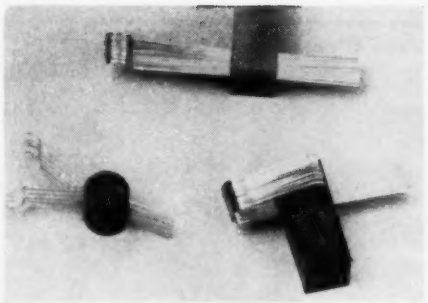
WORTH FILING

Servo Calculator

A "Servo Calculator" which you can use as a plotting tool aid in the solution of network problems in servo analysis may be obtained by design engineers at no charge by writing Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N.Y. on company letterhead.

Servo Charts

A series of charts which will help you select transistor/magnetic servo amplifiers for various error signal inputs and servo motor loads may be obtained at no charge by writing Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N.Y.—Request Bulletin S-817A.



Molded Contact Assemblies

Cost savings in assembly operations and greatly increased reliability result from the use of new molded contac' assemblies announced by The J. M. Ney Company, precious metal manufacturers. These assemblies, designed for use with printed commutators, potentiometer windings, slip ring assemblies and printed rotary switches, are available in a line of standard molded brush assemblies or can be designed to customers' specifications. Seven outstanding advantages are (1) complete single or multiple brush assembly, (2) elimination of welding or soldering, (3) reduction of adjustment during customer's assembly, (4) insured uniformity of desired gram pressure, (5) reduced inspection costs, (6) use of Ney's reliable time-tested precious metal alloys. The J. M. Ney Company, Hartford 1, Conn.

Circle No. 217 on Inquiry Card

WORTH FILING

Thermocouple Data Catalog

Supplemented by charts and pictures, a data catalog describes thermocouples for use in the nuclear, missile aircraft, industrial and process fields with emphasis upon the special AerOpak ceramic insulated thermocouples. The choice of diameters, materials, typical connectors, junctions and terminations is specified.

Source: Aero Research Instrument Co.

For your copy: Circle No. 248 on Inquiry Card

Chicago, Illinois

WORTH FILING

"Terminalogy"

Free subscription to the bi-monthly "Terminalogy" bulletin devoted to terminal and connector developments and applications, is available to anyone engaged in radio-electronic or electrical work. The third issue of "Terminalogy" unveils the revolutionary "Conhex" subminiature r.f. cable connector which represents a decade and a half of intensive specialization.

Source: Sealectro Corporation
Mamaroneck, N. Y.

For free subscription: Circle No. 218
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and tiny
Save SPACE
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The A. W. HAYDON COMPANY'S unique Line of
RELIABLE SUB-MINIATURE REPEAT CYCLE TIMERS
TINY!
1 x 2 inch cross section
6½ ounce basic weight
Up to 10 switches
TOUGH!
Temperature: 54 C. to 85 C.
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Hermetically Sealed Housings! Direct Current or 400 Cycle Operation! Custom Designed to Meet Military Specifications!
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CIRCLE 23 ON INQUIRY CARD

Design Electronic Controls for RELIABILITY IN SERVICE with Alden Components for PLUG-IN UNIT CONSTRUCTION

Be sure your Engineers are working with the Alden Handbook of plug-in unit design. Presents complete line of basic components of tremendous flexibility for adapting your equipment to plug-in construction.

REQUEST FREE 250-PAGE "ALDEN HANDBOOK"

1. *Unitize your circuitry in compact vertical planes using Alden Terminal Card Mounting System.*

PREPUNCHED TERMINAL MTG. CARD
MINIATURE TERMINALS
JUMPER STRIP Eliminates wiring for common circuits
CARD-MTG. SOCKETS
YOUR COMPLETED CIRCUITS FOR PLUG-IN PACKAGE OR CHASSIS

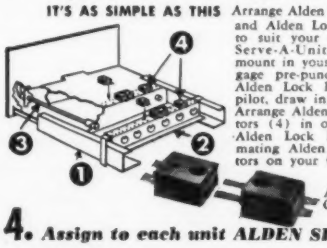
You can use Alden Terminal Mounting Card with Alden Miniature Terminals, Jumper Strip and Sockets staked to accommodate any circuitry — making complete units ready for housing. Components snap into unique Alden Terminals, are held ready for soldering.

2. To mount this vertical circuitry, ALDEN PLUG-IN PACKAGES AND CHASSIS give tremendous variety with standard components

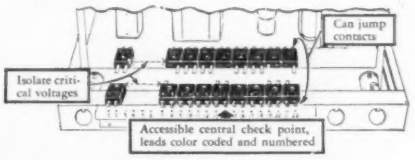
Alden components provide standard plug-in or slide-in housings—with spares, your circuits become units replaceable in 30 seconds.

3. Give chassis easily traceable interconnects and 30-second replacement with ALDEN SERVE-A-UNIT KIT

IT'S AS SIMPLE AS THIS Arrange Alden Side Rails (1) and Alden Lock Frame (2) to suit your chassis. Alden Serve-A-Unit Locks (3) mount in your chassis to engage pre-punched holes in Alden Lock Frame (2) to pilot, draw in, lock or eject. Arrange Alden Back Connectors (4) in orderly row on Alden Lock Frame. Mount mating Alden Back Connectors on your Chassis.



GIVING YOU 1) Chassis that plugs in, locks and ejects with half turn of the wrist. 2) leads so beautifully organized, accessible and identified that non-technical personnel can service.



4. *Assign to each unit ALDEN SENSING ELEMENTS — to spot trouble instantly:*

11138 N. Main St., Brockton 64, Mass.

ALDEN PRODUCTS CO.

From Alden's Line of Ready-made Components for Unitized Plug-in Unit Construction.

CIRCLE 24 ON INQUIRY CARD

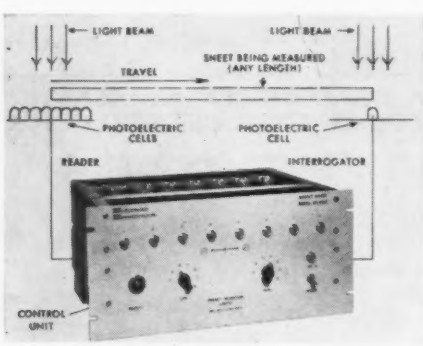
MISCUT GAUGE

Photocells Trigger Reject Mechanism

A miscut gauge control system automatically measures the length of steel sheets moving along a conveyor belt at speeds up to 50,000 ft/sec and rejects short or long sheets.

When the control unit measures a sheet that is out of tolerance, an output signal actuates an alarm and operates an automatic reject system taking the sheet off the line. Accuracy of the system is ±0.003 inch and is completely independent of the speed of the conveyor line. Rated for continuous operation, the system adapts equally well to non-ferrous metal, plastic, paper, rubber, textile or other material fabrication processes where accurate dimensional control is desired.

Packaged modules contain the electronic portions of the system so that regular in-plant personnel can make any necessary repairs.



An interrogator photocell and a bank of reader photocells, positioned along a conveyor belt, operate so that as the leading edge of a sheet crosses the interrogator position, the trailing edge is positioned over the center of the reader bank. Breaking the interrogator light beam energizes the reader bank of photocells. For every cell covered by the steel sheet, a corresponding panel light glows. Since the photocells in the reader bank are spaced on 1/32 inch centers, each pilot lamp on the control panel represents a 1/32 inch increment of length.

Circle No. 66 on Inquiry Card

Aluminum RF Coaxial Plugs

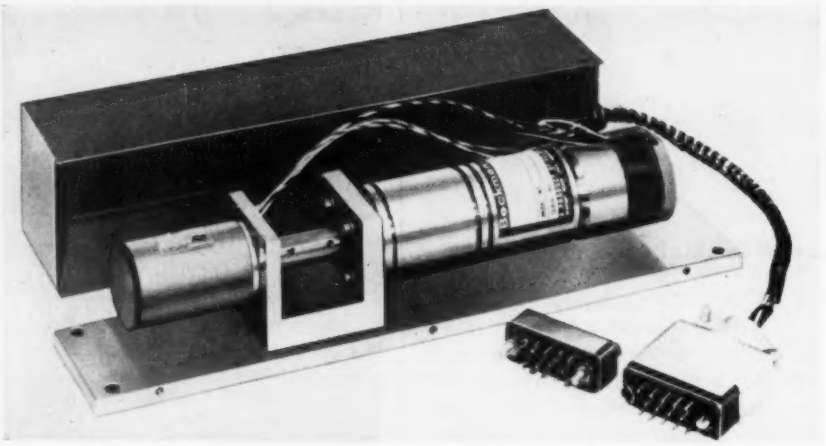
A series of lightweight RF coaxial connectors utilizing aluminum shells has been prefixed "AL" (for aluminum) and added to the standard Cannon N and SC coaxial lines. Both ALSC and ALN plugs accept RG coaxial cables and the latter also accommodates Foamflex and Raytherm types. The moisture sealing characteristics and electrical performance of the new plugs are superior to those of the brass-shell N and SC series. In addition, Cannon claims these general advantages:

- 35 to 40 per cent lighter weight than comparable RF coaxial plugs
- an improved clamping mechanism which does not distort the cable dielectric
- a black anodic coating for maximum corrosion resistance.

Cannon Electric Co., L.A., Cal.

Circle No. 130 on Inquiry Card

Integrator-Drive Assembly Uses Black Box Technique



Servo-positioning devices, until recently designed and assembled as needed by systems engineers, can now be procured in black box form from the Helipot Division of Beckman Instruments Corp. Their first effort along this line is a small, integrator-drive assembly developed for use by Chance-Vought in laboratory test equipment for the Regulus II guided missile.

Chief advantages of the new integrator assembly are that it saves space and eliminates the necessity of positioning, testing and aligning individual components.

Used in the assembly is a 115 volt, 400 cycle motor-generator with stall torque rated at 0.63 oz-in. 1.3 gm-cm² rotor inertia produces acceleration at stall of 34,200 rad/sec.². Motor power input is 4 watts; the generator requires 3.6 watts.

A series AJ precision potentiometer with a total resistive range to 10,000 ohms ±5%, and a linearity tolerance of ±0.5% produces correct output voltage in the assembly.

A gearhead clutch slips at 20 oz-in and, since the potentiometer stops can take up to 50 oz-in, there is no chance of damage to the potentiometer should the system accidentally be driven into the stops.

Applications for integrator-drive assemblies include all types of balancing, positioning and computing servos . . . in fact, they can be used anywhere that an electrical output corresponding to shaft input is desired.

Circle No. 74 on Inquiry Card

WORTH FILING

Utility Packaged Amplifier

16-page booklet specifies operational characteristics of a d-c amplifier contained in a general-purpose utility package. Error factor theory is discussed and functional schematics of systems which can use the amplifier are outlined, i.e: amplifier-attenuators, adders, summing integrators, double integrators, precision oscillators and differentiators.

Source: Philbrick Researches Inc. Boston, Mass.

For your copy: Circle No. 132 on Inquiry Card

Low Light-Level TV Camera

A closed-circuit television camera that can "see" in almost total darkness without the use of separate infra red light source, owes its extremely high sensitivity to the use of a newly developed image orthicon tube and new electric circuitry. The tube can "see" a subject with only 1/1,000,000 of a foot lambert of light present. A high gain pre-amplifier then amplifies the image to a usable level. Both tube and the pre-amplifier minimize snow on the screen. The basic difference between the tube and the other low light-level tubes is that this has a special target with a principle of operation that involves electronic rather than ionic conduction. This special target is capable of better image integration because of its high lateral resistivity. At the lowest operating light level, the camera will provide a picture of 200 lines resolution; the maximum resolution possible is better than 800 lines. The cylindrical camera weighs 30 pounds, is 20 inches long and 7½ inches in diameter, and is available for color or black and white. GE, Schenectady, N.Y.

Circle No. 186 on Inquiry Card

MATERIALS

HIGH TEMPERATURE ALLOY

Weldable, Formable, Hi-Strength Alloy for Use at 1800F

A nickel base, titanium-aluminum high temperature hardened alloy has evolved in the battle to smash the thermal barrier. Its high temperature capability makes possible higher jet engine and airframe Mach numbers at lower specific weight.

Trade marked René 41, the alloy was developed jointly by the General Jet Electric Company's Jet Engine and Flight Propulsion Laboratory Departments. Although René 41 high temperature alloy was designed for use in severely stressed jet engine components, its high temperature strength makes it ideal for many applications where high temperature resistance and performance reliability are required. Despite its fairly large content of titanium and aluminum, René 41 can be formed, welded and machined with relative ease in comparison with other materials designed to operate in this temperature range. Usable in the 1800F range, which is considerably higher than currently used sheet metals of comparable rupture strength are capable of, the new alloy also can be used effectively through the entire range from room temperatures to 1800F by appropriate heat treatment. Welding offers no major problems to the new alloy. It can be inert-arc welded with or without filler material and can also produce strong, ductile spot welds. Welds closely approach the strength of the base metal.

The mechanical properties of the metal are expected to make it an excellent high temperature bolting and fastener material and desirable for high Mach airframe components. René 41 offers a 40 to 60 per cent improvement in sheet tensile strength over existing commercial types at 1000-1400F, yet it can be produced with relative ease in sizes required to manufacture large sheet metal components. Strength tests of the new metal with optimum heat treatment show that the 0.2 per cent offset yield strength at 1200F is 125,000 pounds per square inch. The 100 hour stress rupture strength at 1600F is 25,000 psi. General Electric Company, Schenectady, New York.

Circle 157 on Inquiry Card

Synthesized Yttrium-Iron Garnet

Reflecting an advance in the synthesis of an inorganic substance having application in the electronic field, a compound termed polycrystalline yttrium-iron garnet ($Y_3Fe_5O_{12}$) is a relatively high-density, nonporous material consisting of tightly-bonded, sintered crystallites whose crystal structure is identical to that of natural garnet. Yttrium-iron garnet has been found particularly suitable as a replacement for ferrites in such devices as parametric amplifiers, rotators, phase shifters, isolators, etc. Since this substance has a line width which is very narrow, applications requiring narrow-band operation in the 10 KMC frequency region may find yttrium-iron garnet ideal. Further, since the lower limit of operational frequency depends upon line width, low-frequency operation at approximately 1 KMC and below is possible. The finished material is easily ground to any shape and size, has zero weather absorption, and a density which is greater than 96 percent of theoretical. Kearfott Company, Inc. Clifton, New Jersey.

Circle No. 117 on Inquiry Card

Short Ceramic Coil Form

A series of six new 1½ inch ceramic coil forms has been developed by Cambridge Thermionic Corp. for use where the extra length of their otherwise identical 1-11/16 inch Cambion LS7 form is unnecessary. A beryllium-copper locking spring device maintains constant tension on the tuning core, and adjustable ring terminals or silicon Fiberglas terminal collars with one to four solder lugs are also available. Made of brass with cadmium plate—metal parts being non-ferrous and electro-plated—all the coil forms meet military specifications. Cambridge Thermionic Corp., Cambridge, Mass.

Circle No. 122 on Inquiry Card

Manufactured Graphite Handbook

A comprehensive handbook of technical data on manufactured graphite makes available to design engineers considerable information to help in the selection of the proper grade for any particular application. Presented in the handbook are graphs, tables and curves relating uses of the various graphite materials in the chemical processing, metallurgical, electrical, and nuclear fields. Printed in loose-leaf form, the handbook will be kept up to date with the periodic release of supplementary data.

Source: National Carbon Company
Niagara Falls, New York
For your copy: Circle No. 131 on Inquiry Card

NEW Chromalox Electric Microfins® for forced convection air heating

This new, small-mass heater provides rapid heat-up almost equal to open coil elements. Unlike open coils, however, Microfins offer the advantages of a totally enclosed and insulated element only ¼-inch in diameter.

Microfins are ideal for air ducts and blower type space heaters, such as those used for industrial ovens and dryers. Their easy formability and high watt density (up to 80 watts/sq. in.) permit Microfins to pack maximum heat output into minimum space.

Standard lengths from 5½ to 47½ inches; 120 and 240 volts; 525 to 3000 watts. Specials available as required.

Get more information from your Chromalox Representative or write today.

2674

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EDWIN L. WIEGAND COMPANY
7900 THOMAS BLVD., PITTSBURGH 8, PA.

CIRCLE 25 ON INQUIRY CARD

ELECTRIC ARC "PLASMA SPRAY"

Coating Technique Sprays Vaporized Tungsten onto Cold Steel

The compelling need for more practical methods of fabricating high-temperature, high-stress materials has been partially satisfied by a new technique which makes use of the fourth state of matter to vaporize and spray any known element or combination of elements onto a support material, overcoming previous temperature restrictions imposed by oxyacetylene torch techniques.

Developed by the Giannini Plasmadyne Corporation, the new spraying process directly transfers energy from an electric arc to an ionized gas medium, creating temperatures up to 25,000F—six times the heat of a blast furnace—at velocities of 13,000 ft per second. At this temperature tungsten converts from the vapor state to the plasma state, the fourth state of matter.

A remarkably lucid explanation of the fourth state of matter (other three states, of course—solid, liquid, and gaseous) was presented by Wolfgang Finkelnburg in June 1956 at a high temperature symposium held at the University of California at Berkeley. In his explanation he considered the change in the behavior of a gas such as nitrogen caused by increasing its temperature. Up to about 2000K an increase in the random thermal vibrations of the gas molecules occurs. At 7000K the state of the gas has already changed markedly. About one-third of the original N_2 molecules are split into N atoms by thermal dissociation and the intense radiation of the gas shows that the electron shells of the atoms and molecules are excited thermally. The gas still remains a fairly good electrical insulator; only about one percent of the atoms or molecules have lost one of their outer electrons due to the high temperature. At 12,000K there are practically no more molecules because of their complete thermal dissociation. By this time one-seventh of the original nitrogen atoms have lost one electron by thermal ionization. Existence of free electrons and positive ions creates considerable electrical conductivity. At about 20,000K double ionization sets in, causing formation of N^{++} and at 30,000K 60 percent of the gas particles already are free electrons. Remaining particles are divided evenly between singly and doubly ionized nitrogen atoms; neutral nitrogen atoms have practically disappeared. The temperature rise produces a fundamental change in the composition and properties of the original gas, justifying the introduction of the new concept of *thermal plasma as a fourth state of matter.*

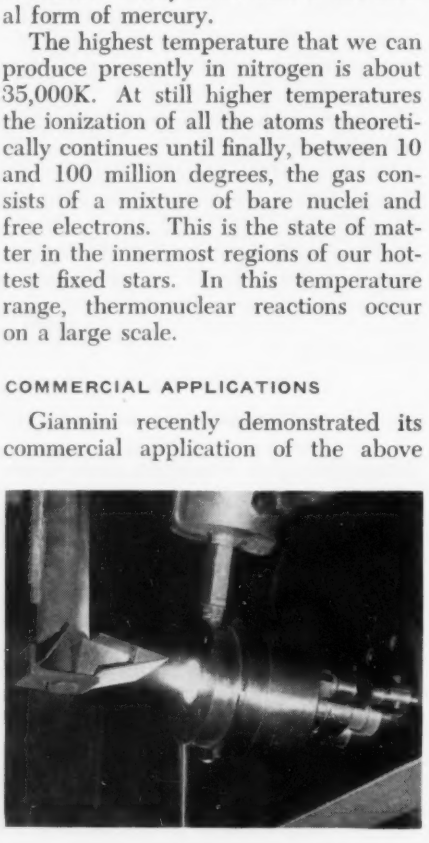
Consider these radical changes: The particle density of the gas has fallen to one percent of the original value, at the same pressure, as the absolute temperature exceeds the original temperature 100-fold. Only about one-third of the new gas particles are heavy particles having approximately the same mass as the nitrogen atoms. The rest of the gas consists of nearly mass-less electrons. Mean molecular weight of the gas has consequently fallen from about 28 to barely 5. Its actual density measured in grams per cc has fallen to about two per 1000.

At all temperatures above 6000K a large number of chemically active nitrogen atoms or ions are present. At such a high temperature matter radiates intensely, a fact now used in modern thermal light sources such as mercury arcs, high pressure zenon arcs, and other arc lamps. While the initial nitrogen gas is an excellent electric insulator, the thermal plasma is an excellent electric conductor. Its specific resistance is only twice that of the metal form of mercury.

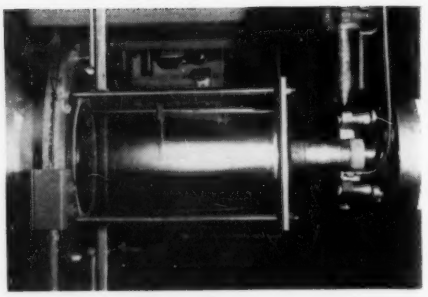
The highest temperature that we can produce presently in nitrogen is about 35,000K. At still higher temperatures the ionization of all the atoms theoretically continues until finally, between 10 and 100 million degrees, the gas consists of a mixture of bare nuclei and free electrons. This is the state of matter in the innermost regions of our hottest fixed stars. In this temperature range, thermonuclear reactions occur on a large scale.

COMMERCIAL APPLICATIONS

Giannini recently demonstrated its commercial application of the above concept when it vaporized tungsten, converted it from the gaseous state to the plasma state and sprayed it onto cold steel.



Aerodynamic wind tunnel specimen of molybdenum — titanium alloy being coated with molybdenum disilicide utilizing the Plasma Spray process.



Plasmatron wind tunnel facility makes possible the study of hypersonic flow, re-entry simulation, and material testing. Standard plasma-generating head is coupled to an evacuated chamber and equipped with a water-cooled, hypersonic nozzle. An accessory test section allows removal of the specimen to a point outside the main chamber area. The head mounts so that it can be removed for access to the specimen area. Material test specimen is undergoing ablation study.

According to H. C. Sullivan, Manager, Materials Technology Laboratory at Giannini Plasmadyne Corporation, tungsten was chosen for the demonstration because its boiling point—10,600F—is higher than any other element in the periodic table. Completely out of the range of an oxyacetylene torch, this is probably the first time that tungsten has ever been vaporized and sprayed in this manner.

After the tungsten spray was fired onto its base material at high velocity, it was observed to adhere extremely well, creating a tightly packed, smooth surface. Unlike chemical combustion processes, the inert jet does not contaminate or oxidize the coating or support material.

Remarkably strong surface bond, packing density, and surface smoothness is attained by the combination of high spray temperature and velocity. Controlled spray coatings also allow the matching of thermal expansion properties of different base materials with surface protection able to withstand the intense temperatures encountered in the missile, aircraft, and nuclear reactor fields.

The technique will provide low-cost, light-weight protection of exposed structural metals, high-temperature pump and bearing surfaces, combustion-chamber valves and liners, high-speed grinding and cutting surfaces, high-temperature wiring insulation and almost any material surface which requires thermal qualities or density not afforded by the structural support medium.

Circle No. 41 on Inquiry Card

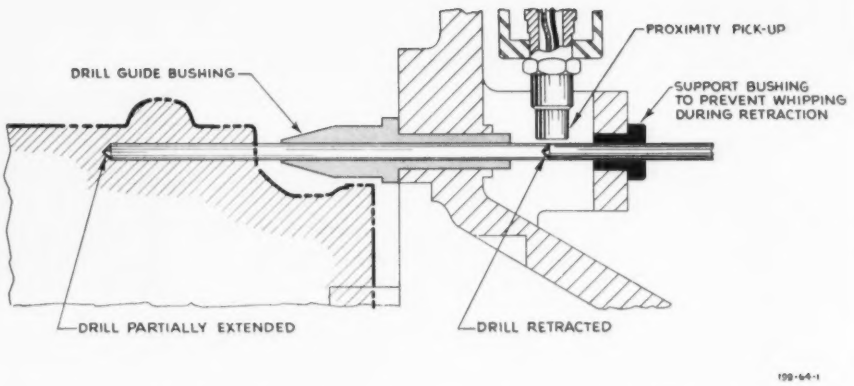


Fig 1—Because the small drills are also long, a special support bushing is used to prevent whipping when they are retracted. A proximity pick-up is located over the point of the drill when it is fully withdrawn and continuously checks drill condition. The metal of the drill is a part of the electrical checking circuit.

AUTOMATIC DRILL MACHINE

Proximity Switches Signal Slender Drill Breakage

Any small drill is vulnerable to breakage. One that has a length-to-diameter ratio of 50:1 is especially ripe for production troubles. An automotive-parts manufacturer, however, has been able to economically drill ¼-inch holes, 7¾ inches deep, with an automatic machine developed and built by Buhr Machine Tool Co., Ann Arbor, Mich.

Because the hole diameter was not critical, Buhr engineers were able to reduce tool breakage by drilling the hole in five passes. Each pass adds to the depth of the hole but with a slightly smaller diameter. The last pass is made with a ¼-inch drill and completes the hole to depth.

By gradually decreasing the drill diameters in this way, Buhr engineers have reduced rubbing and assured good clearing of the chips. For a hole having these dimensions, a single, long ¼-inch drill would have to be withdrawn several times during drilling. Otherwise, rubbing and packed chips would cause high breakage rates.

Depth of the hole added by each of the five steps was carefully computed so total cycle times for each pass were the same. This has resulted in optimum infeed rates, cutting speeds, chip loads and thrusts consistent with each drill diameter.

The long, slender drills are supported and guided by bushings during the drilling stroke. To prevent them from whipping and breaking during retraction and part indexing, a second support bushing is located at the back of the bushing plate, Fig 1.

DRILL CHECKS

Since it would be time-consuming and costly to probe holes for broken drills after each drilling step, Buhr engineers designed the machine to continuously check drill condition. A proximity switch pick-up is located at a set distance from the drill and between the two bushings, Fig 2. When the drill is fully retracted, its point comes under the midpoint of this pick-up.

The metal of the drill provides a path for flux lines which initiates an electrical circuit. If the drill breaks, the circuit is broken and a resulting amplified signal shuts down the machine. A red lamp glows to indicate which drill is broken.

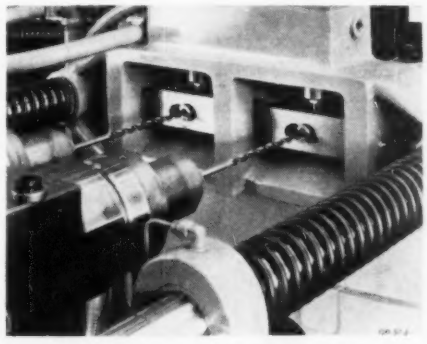


Fig 2—Proximity switch is visible just over the rear, support bushing. Buhr Machine Tool Co. designed and built this Economatic to minimize operating costs where excessive drill length-to-diameter ratios made broken drills a real problem.

There is no chance for machine or workpiece damage because when a drill breaks a control relay in the "Index" and "advance units" circuits opens to completely stop the machine cycle. Proximity control units are reset simply by replacing the broken drill. When the proximity control circuit is again closed, the control relay automatically closes and the machine is again ready for operation.

A selector switch is located at each of the hydraulic feed units so proximity switches for that unit can be by-passed during setup and maintenance operations.

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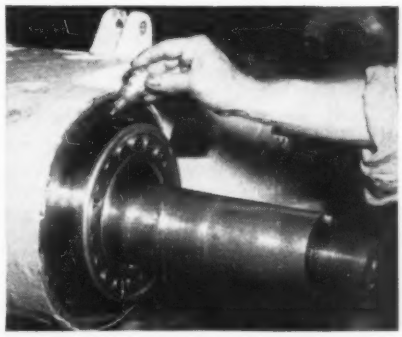

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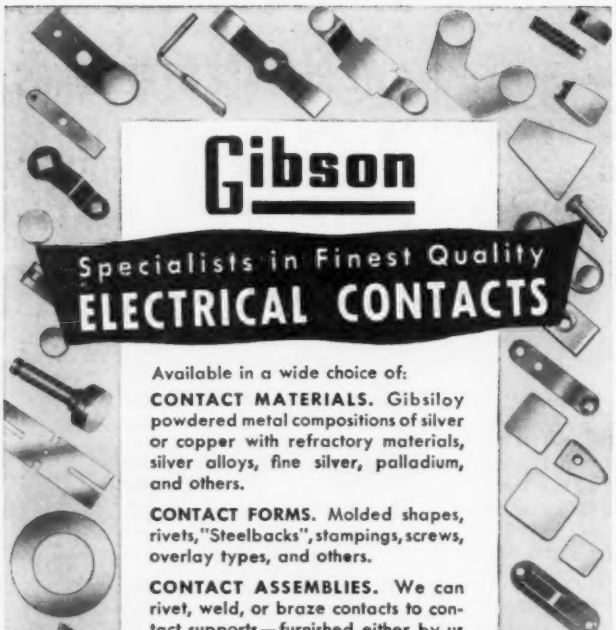
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STAFF COLUMNIST

David Bandel
Associate Technical Director,
TRACERLAB, INC.

PROGRESS IN PRINTED CIRCUITRY: Part 3

Silver Migration and Printed Wiring, a paper presented by S.W. Charkin, J. Janney, F.M. Church and C.W. McClelland of Stanford Research Institute, and sponsored by the Signal Corps, summarizes an extensive investigation of the migration of silver across and into insulating materials. The original observations on silver migration were made by Bell Telephone Laboratories, Lincoln Laboratory and Squier Signal Laboratory.

Generally, high d-c potentials and high humidity favor silver migration with high relative humidity being a prime factor. Initial experiments using silver foil on XXXP laminate indicated silver migrated extensively into the laminate only at the anode when subjected to a 480 v. d-c potential at 89% relative humidity and 35°C. Close examination of the laminate showed the surface of the fibrous filler in the XXXP laminate was darkened and chemical analysis confirmed that the darkening was due to silver deposited on the fibers. A series of tests at varying relative humidity showed that silver migration decreased markedly as the relative humidity decreased. Below 75% relative humidity, no migration of silver was found even at 480 v. d-c potential. Under extreme conditions of humidity and voltage—96% relative humidity and 480 v. d-c—failure occurred in some cases by tracking and splattering of molten silver due to arcing. Reducing the d-c potential to 22½ volts decreased silver migration but it was still extensive at high humidity. At 6 v. migration was barely perceptible. A-C potentials cause far less migration of silver and in general, silver migration is no problem where only a-c voltages are applied.

Various base materials tend to support silver migration. In general, non-filled plastic boards resisted silver migration. Epoxy-glass laminates showed slight migration, mainly on the glass fibers, teflon-glass moderate migration on the glass fibers and phenolic-cellulose filled heavy migration on the cellulose fibers. Surprisingly, Nylon grade 6503 showed heavy migration on the surface. In contrast, nylon fiber-phenolic laminate was highly resistant to silver migration, even where the nylon fibers were exposed by milling the surface off the laminate, possibly as a result of differences in the types of nylon. Nylon 6503 is a type 6 nylon, made from polycaprolactam, which has high water absorption; the nylon fiber used for the phenolic laminate was a 66 nylon, which has a much lower water absorption. Melamine-glass fiber laminates showed extensive silver migration in the glass fibers.

Standard air drying silver paints migrated as extensively as the silver foil. A new silver ink developed by the Wornow Process Paint Co. is superior in resistance to migration. This paint is applied as two separate formula-

tions; the first coat is air dried at room temperature and the second coat oven-cured for one hour. Silver migration with this paint was slight on XXXP board but very extensive on Mycalex-400 and -500.

Silver plate migrated as extensively as foil and paint with epoxy-glass laminates showing extensive migration. This was the only case where migration came from the cathode rather than the anode. Dip-soldering over the silver plate eliminated migration on all boards. The tin-lead solder probably alloyed with the silver. Previous tests had shown that the silver-bearing solders do not migrate. Electroplating copper on chemically deposited silver reduced general migration but migration still occurred in localized spots along the edge of the conductors selected as anodes for the experiments.

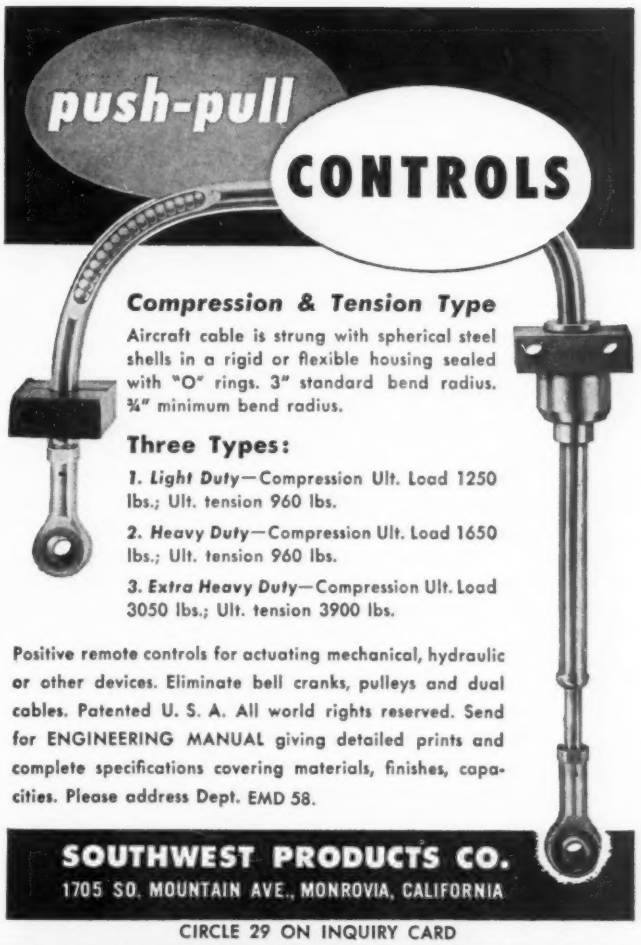
METHODS OF INHIBITING SILVER MIGRATION

•*Silicon Emulsions.* The electromechanical process by which migration occurs requires the presence of water. This is a hypothesis supported by the necessity of high humidity for migration and the general observation that plastics that absorb moisture most readily show high silver migration rates. Treatment of the laminate boards with silicone emulsions showed considerable inhibition of migration. The optimum treatment consisted of immersion of the laminate in Dow-Corning Silicone F4141 diluted 1:10 for 1 hour, rinsing in distilled water followed by curing for 30 minutes at 65° C. It was estimated that silver migration was reduced 75% over the controls. Other silicone products were less effective in inhibiting migration.

•*Silver Alloys.* Silver-tin alloys in the form of Ag_3Sn did not show any migration. Silver-copper alloys were tested to determine whether these alloys would also resist migration. Coin silver, a silver-copper alloy containing 10% copper was tested on XXXP and glass-bonded mica. The results showed that on both of these boards, where pure silver migrates extensively, only very slight migration occurred with an estimated reduction of migration of 0.1-1.0% of pure silver under similar conditions. The inhibiting action of copper may result from copper concentration at the surface increasing very rapidly during the early part of silver migration because of the depletion of silver at the surface. The resultant invisible copper sheath keeps the silver out of contact with the surface of the board. This would account for the slight amount of silver that migrates and the cessation of silver migration at such a low level. Lower copper concentrations in the alloy did not inhibit the migration of silver, at least 10% copper was required for effective reduction. The eutectic alloy 72:28 silver:copper was not noticeably superior to the coin silver alloy in reducing migration. Other alloys, containing gold, 5% tin, antimony and cadmium were ineffective. Lead, 15% tin and platinum produced a slight reduction in migration.

SUMMARY

The best means of avoiding silver migration in printed wiring is to use boards which do not support migration under any conditions; Teflon, Kel-F, nylon-filled phenolic laminate and polystyrene; use copper-silver alloys with 10% or more copper; gold and cadmium plate over the silver. Silk screening is a very neat way to produce printed wiring boards and once the problem of silver migration has been settled it should find extensive application in the electronics field.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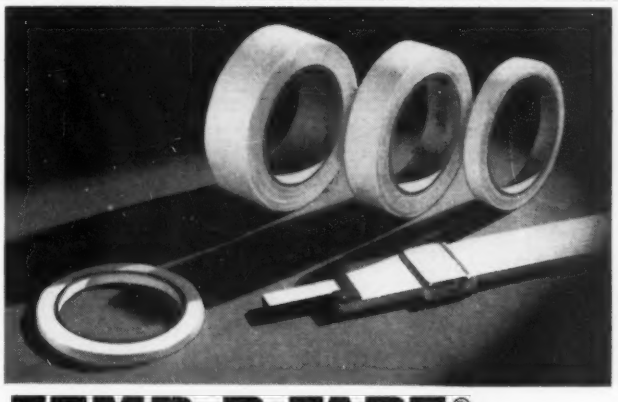

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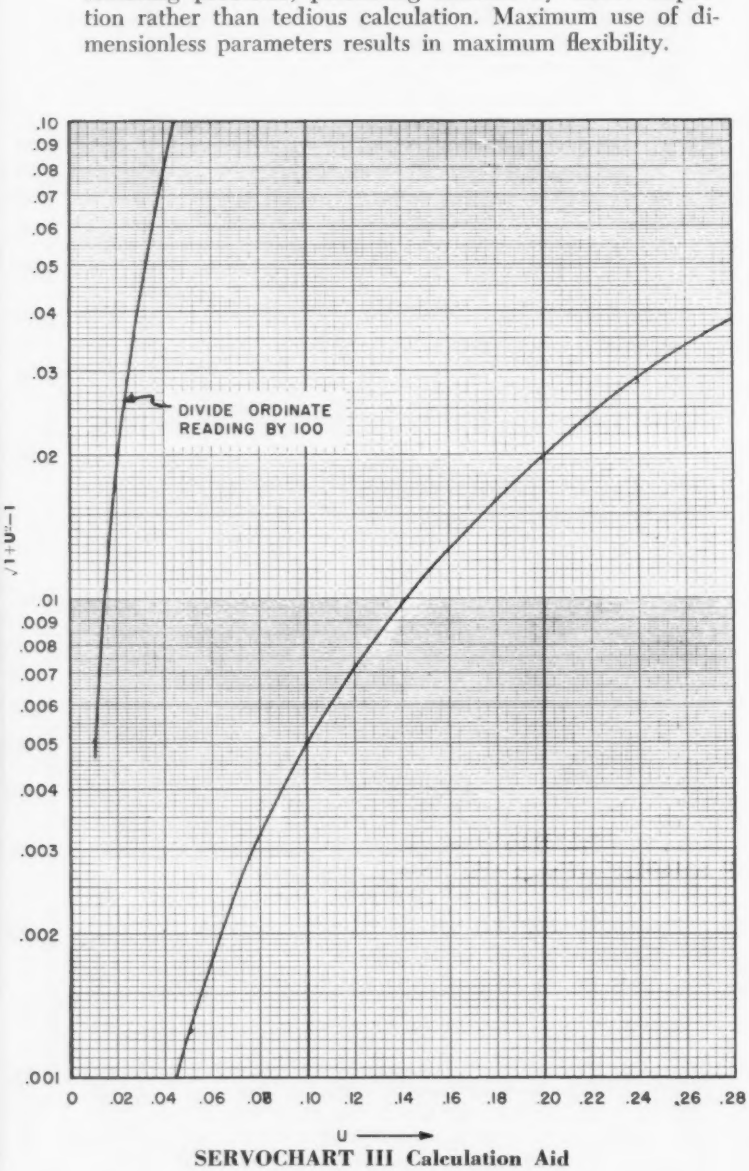
CIRCLE 33 ON INQUIRY CARD

DESIGN TIME SAVER

Servo Design Charts

This issue continues the series of Servocharts started in our July issue. These self-contained charts will ultimately constitute a balanced set, applicable to meet servomechanism design problems. They will apply to specific though recurring problems, permitting solution by direct inspection rather than tedious calculation. Maximum use of dimensionless parameters results in maximum flexibility.

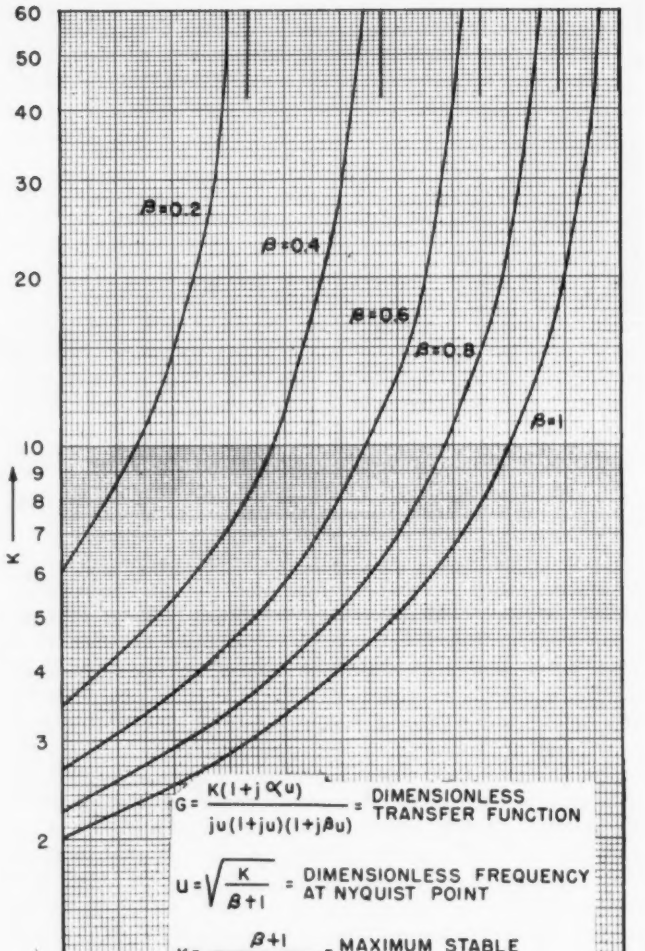


SERVOCHART III Calculation Aid

Calculation of $\sqrt{1+u^2}$ for very small values of u. Use in determining effect of small additional time constants on magnitude of transfer function.
For example, for u = 0.08,

$$\sqrt{1+0.08^2}-1=0.0032, \text{ or}$$

$$\sqrt{1+0.08^2}=1.0032$$



SERVOCHART IV Maximum Stable Loop Gain
u = frequency on dimensionless basis
α, β = per unit values of 2nd and 3d time constants
K (as plotted) = max gain at 180° phase shift for stability

Servochart IV indicates the maximum stable open loop gain for a type I servomechanism with two time constants and a lead term. The transfer function in general form is

$$G = T = \frac{K_V(1+pT_2)}{p(1+pT_1)(1+pT_3)}$$

This expression is reduced to dimensionless form in terms of frequency as shown on the chart by the following substitution of variables:

Let $P = jw$ $\quad T_2/T_1 = \alpha$
$wT_1 = u$ $\quad T_3/T_1 = \beta$ $\quad K_VT_1 = K$

This equation may be solved for that value of u yielding a 180° phase lag for G, which value may then be substituted back into the equation. For borderline stability, $|G| = 1$. Therefore K may be determined for this condition as a simple function of α and β. The servochart shows this function as a family of curves.

In a specific problem, simply determine α and β as the ratio of the secondary time constants to the primary time constant. The servochart will directly indicate K or K_VT_1. If the primary time constant is known, the theoretical maximum servo velocity constant is determined. It is common practice to allow a factor of safety of about 2 in setting this velocity constant.

STAFF COLUMNIST

Herbert F. Spirer

Assistant Chief Engineer
CGS Laboratories, Inc.
Stamford, Conn.

U-DRIVE-IT-ENGINEERS

Some people call them "U-Drive-It-Engineers". They are also called contract engineers or job shop engineers. The Sales Representatives who place them are often known as flesh peddlers—a term they do not resent. These engineers-for-hire (and draftsmen, designers and almost any other talent) have become, in the last few years, increasingly important in the design and development of mechanical, electrical, electromechanical and electronic equipment.

The job shop engineer is like any other engineer who works in your plant or laboratory, except that you pay him only for hours worked and for some living expenses. You do not pay him directly and you can release him on a few days notice. In these exceptional items he is like a consulting engineer whose services you might obtain from a consulting firm. But again he differs. The job shop engineer works in your plant directly under the supervision of your line authority and, aside from pay-roll considerations, is treated the same as any other employee.

The cost of these services runs from $7.00 to $9.50 per straight-time hour, including travel and living allowance. This figure also includes overhead which is primarily the administrative costs of the agency, sick leave and holiday pay, fringe benefits and profit. Job shoppers are invariably paid overtime, no matter the level at which they work—and the employer is generally charged at a higher rate.

Why should any company pay these prices?

- Peak load requirements for manpower may greatly exceed the desired permanent staff. So the company brings in job shoppers to obtain their engineering services without long term commitments.
- Some companies have undesirable locations in which engineers do not want to make permanent commitments, and the company can obtain in this way specialized talent not ordinarily available in its area.
- Many companies turn to job shops out of sheer desperation. Unable to get or hold sufficient engineers to meet an immediate commitment, these companies get the necessary services on a job shop basis.
- The company can dismiss rapidly—on one to seven days notice—with no liability an engineer whose services are no longer necessary or adequate.

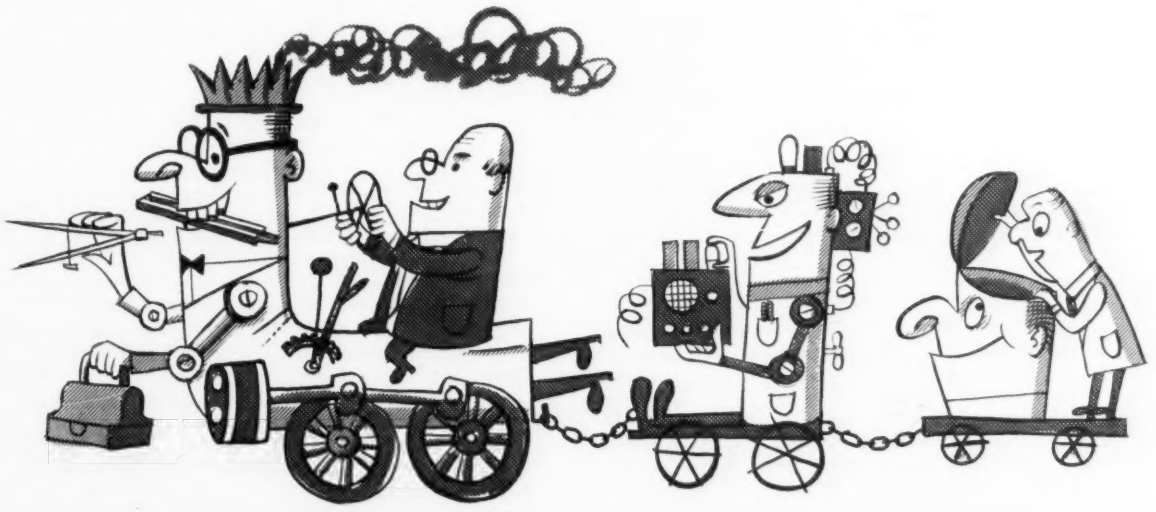
Job shopping can be a means of permanent recruitment. Frequently the company can come to terms with an agency and make a job shopper an offer of permanent employment. If not, agreements with agencies usually contain some provision about rehiring an engineer on a non-job shop basis after his employment on the premises has been terminated for a specified length of time. With the present cost of engineer recruitment many companies are willing to pay the premium necessary to obtain permanent personnel through this means.

Why should a job shop be able to attract engineers when a company offering continuous employment cannot? The agencies are, of course, usually more skilled in recruiting and maintain a large, specialized staff engaged in recruiting. However, the most important reason is money. The job shop engineers usually earn a base rate 20 percent higher than they would get in direct employ plus an expense allowance which can represent another 20 percent of extra income.

The use of these people is not an unalloyed joy. Employment of job shoppers may have serious effect on the morale of the permanent staff. Working at the side of the "captive" (permanent) engineer in the same administrative set-up on the same type of work, the job shop engineer receives more salary. The permanent professional rarely receives pay for overtime, and if he does, only at straight time rate. The temporary engineer invariably receives overtime at about 1½ times the straight time rate. The permanent employee is told he has security, but knows of many examples where permanent employees have been dropped and the temporary retained.

For most companies the use of this type of labor is not a choice but a necessity. I predict that use of these engineers will increase. More and more competent design engineers will turn to this kind of employment because of the higher pay. If this trend does continue, job shop employment may do more to raise the level of engineering wages than any union-type organization.

Next month I will discuss in detail the pay scale of job shop engineers and the unwritten ethical code that may make the job shop engineer a more reliable employee than the captive.



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Opportunities in radio and communications. National Co., Malden, Mass. Circle No. 34

Flow Indicator ..... **p. 8**
Square root integrator with double disc and ball integrating mechanism and pulse output provides high accuracy and convenient electrical transmission. Librascope, Inc., Burbank, Calif. Circle No. 4

Heaters, Electric Microfins ..... **p. 39**
Small mass convection air heaters offer advantages of rapid heating in a totally enclosed and insulated element—just ¼" diameter. Edwin L. Wiegand Co. Circle No. 25

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Free samples showing sales appeal of decorative chromate dip process for zinc plated small parts. Chemical Corp. Circle No. 9

Metals ..... **p. 15**
Fine wire of ductile and non-ductile materials for every application; thermometals for use in any indication and control of temperatures, electrical currents and voltages; gold immersion solution for depositing a thin layer of 24K gold. Englehard Industries. Circle 30, 31, 32

Motors, Fractional Horse Power ..... **p. 7**
One of the more than 100,000 filled specs on file may meet your electrical, mechanical or cost requirements. Howard Industries, Inc., Racine, Wisconsin. Circle No. 2

Motors, Induction or Synchronous ..... **p. 23**
1/75 to 1/30 hp motors are ideal power sources for recording instruments, timers, medical instruments, office equipment, blowers, tape recorders, communication equipment. National Pneumatic Co., Boston, Mass. Circle No. 13

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Direct drive servo motors eliminate backlash, provide efficient power, allow high-loop gain. Inland Motor Corp. Circle No. 10

Outlets, Electric Power ..... **p. 26**
Tiny connector for standard plugs has barrier to prevent shorts. Kulka Electric Corp. Circle No. 16

Paper, Industrial ..... **p. 8**
Special papers made to exacting engineering specifications. Mosinee Paper Mills Co., Mosinee, Wisc. Circle No. 3

Relays, Subminiature ..... **p. 9**
Subminiature relays with high-precision performance and low power requirements ideal for critical aircraft and missile applications. Elgin National Watch Co. Circle No. 8

Relays, Switches ..... **p. 19**
All types with any physical characteristics of relays, steppers, switches and solenoids. Guardian Electric Mfg. Co., Chicago, Ill. Circle No. 11

Sealants, Liquid ..... **p. 41**
Loctite liquid sealants for slip fittings, bearings, bushings, for hardened sleeves and rotors on shifts; for locking threaded fasteners and studs securely; for sealing against high-pressure fluids. American Sealants Co. Circle No. 26

Servo Components ..... **p. 14**
A miniature motor with solid magnet stator and a high-torque magnetic clutch reduce cost while maintaining performance. Dynamic Instruments Corp. Circle No. 7

Tapes, Insulation ..... **p. 43**
Pressure-sensitive Teflon tapes for class H & C insulation, non-stick or chemical resistant facing. Free sample and data. Connecticut Hard Rubber Co. Circle No. 33

Timer, Repeat Cycle ..... **p. 37**
Tough, tiny, hermetically sealed, direct current or 400 cycle operated unit meets military specifications. The A. W. Haydon Co., Waterbury, Conn. Circle No. 23

Valve, Solenoid ..... **p. 11**
3-way valve with nylon body outlasts, outperforms steel units but costs less. Valcor Engineering Corp. Circle No. 5

Wire, Aluminum Anodized ..... **p. 35**
.0008 to .030 diameter wire with high dielectric coating provides insulation at 800F. Sigmund Cohn Corp. Circle No. 22

Wire Insulated ..... **p. 33**
Polyvinyl chloride, asbestos, silicone rubber, Teflon, Kel-F, polyethylene, and nylon insulation, on copper, nickel, nickel clad copper, nickel plated iron, aluminized iron conductors. Continental Wire Corp. Circle No. 21

Wire Insulation Remover ..... **p. 42**
Non-corrosive super X-Var removes coatings from wire and leaves wire ready for soldering. Fidelity Chemical Products Corp., Newark, N. J. Circle No. 28

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For Your 3-Ring Binder

NEW DATA SHEETS

For your free copy of the data sheets listed on this page, circle the appropriate number of the item on the Inquiry Card.

SMALL TOROIDAL INDUCTORS cover inductance range of 1 millihenry to 17 henries and have a useful frequency range of 60 cycles per second to 50 kilocycles per second. Typical 15-millihenry inductor operating at 9 kilocycles has a maximum Q of 160. Fully encapsulated and hermetically sealed, these inductors measure 1 7/16 inches in diameter x ¾ inch high, and weigh only 2.3 ounces. Arnold Magnetics Corp., Los Angeles, Calif. Circle 140.

SEALED SNAP-ACTING SWITCHES safely operate in explosive atmospheres and are reliable in damp or dusty environments. Developed for missiles and miniaturized apparatus, the sub-miniature switches have a flexible bushing compressed around the pin actuator inside the case, and the halves of the case are bonded together. Unimax Switch Div., The W. L. Maxson Corp., Wallingford, Conn. Circle 141.

MICROWAVE PRESSURIZING WINDOWS retain pressure within the waveguide while remaining transparent to microwave energy. Bulletin gives specifications on choke flange mounted, soldered and special types; ceramic windows and some miscellaneous types. Bomac Laboratories Inc., Beverly, Mass. Circle 142.

VARIABLE PULSER converts any signal source with a repetition rate up to 5 megacycles into standardized pulses of controlled amplitude and duration and can be used as a constant high-frequency source or "clock" in experimental computer systems. Technitrol Engineering Company, Philadelphia, Pa. Circle 143.

TRANSISTORIZED POWER SUPPLIES 100% serviceable are completely described in a four page brochure listing performance characteristics and prices of transformer-cased laboratory models and rack-mounted units for either 60 cycle or 400 cycle operation and for any voltages between 5 and 50 volts at current ratings between 50 and 500 ma. Electronic Assembly Co., Roxbury, Mass. Circle 182.

AUDIO/ELECTRONIC CONNECTORS offer quick, positive disconnect made possible by an improved push-action latchlock device. Resilient ribs along the mating surfaces eliminate circuit noise. Cannon Electric Company, L. A., Cal. Circle 145.

DUAL PRESET COUNTER-CONTROLLERS are designed for coil winding, motor speed control, shearing to length, batching, packaging, stacking by number, variable pulse interval generation, and process programming. Computer Measurements Corporation, North Hollywood, Cal. Circle 146.

MERCURY DIFFUSION PUMP, claimed to be the smallest pump in the only metal mercury diffusion pump line in this country, can maintain a speed plateau of at least 40 liters of air/sec in the $3x10^{-4}$ to $2x10^{-2}$mm Hg pressure range with a peak of 52 liters/sec occuring at 10 microns. Rochester Div., Consolidated Electrodynamics Corp., Rochester, N. Y. Circle 147.

PUNCH VERIFIER allows a tape to be punched and verified in two operations from the ten-key special character keyboard. Useful in off-line paper tape preparation for application in computers and controls, the keyboard locks up when an error is indicated. Digital Service Labs, Torrance, California. Circle 148.

SOLDERLESS TERMINAL BLOCKS, designed for various computer applications and printed circuitry, accept standard "AMP 53" solderless taper pins and are available in any combination of feed-thru-individual or shorting terminals. Electronic Sales Division, DeJur-Amsco Corporation, Long Island City, New York. Circle 149.

VOLTAGE REGULATOR may be used for obtaining regulated voltages from 28 volt d-c lines already available in laboratories. Usable with 28 volt aircraft and missile d-c supplies, the transistorized unit also provides a variable voltage from a fixed voltage supply. Valor Instruments Inc., Gardena, Calif. Circle 159.

PULSE INSTRUMENTS are specified in brochure which includes pulse generators, block units for special-purpose pulse instrumentation, magnetic core testing equipment and electronic counters. Electro-Pulse, Inc., Culver City, Cal. Circle 150.

TEXTILE MOTORS rated from 1 through 5 horsepower are available from GE's small integral motor department for use on looms, roving and spinning frames, warping, twisting and carding machines and other textile machinery. General Electric Company, Schenectady, New York. Circle 151.

SEALED MINIATURE RELAYS are ideally suited to machine tool, industrial electronic, instrument and geophysical applications where dirt or lint conditions make ordinary relays unreliable. General Electric Co., Schenectady, N. Y. Circle 152.

"MEASUREMENTS AND CONTROL", an illustrated brochure, describes instruments for measuring shocks, vibration, pressure, temperature and inertial control. Included in the description are such devices as transducers, amplifiers, vibrators, interferometers, strain gauges, accelerometers, temperature probes and miniature airborne recorders. Gulton Instrumentation Div., Gulton Industries, Inc., Metuchen, N. J. Circle 153.

AUTOMATIC TUBE TESTER utilizes a code-card actuated switch (capable of approximately 10 trillion variables) to set automatically pre-determined voltages and conditions for each tube under test. Automatic decade systems provide unusually wide voltage and circuit combinations, permitting special-purpose tests. This tester will also make special tests to evaluate a tube for specific and/or non-conventional circuits. The Hickok Electrical Instrument Company, Cleveland, Ohio. Circle 154.

TANTALUM CAPACITORS operate over a temperature range of −80C to +85C. Available in capacities of 47 mfd at 6V and 6.8 mfd at 35V, these sintered anode subminiature capacitors meet environmental specifications of MIL-C-3965. Minitronics Corporation, New York City. Circle 155.

HAND TACHOMETER takes speed measurements in laboratories, test beds and quality control or production tests. With full scale deflection accuracy of ±0.25 percent, the tachometer has a 4.7 inch dial diameter and its 0.27 inch drive shaft is equipped with ball bearings. James G. Biddle Co., Philadelphia, Pa. Circle 163.

ULTRASONIC CLEANERS, claimed to be the first complete line, are available in 35 watt to 2.5 kilowatt systems. Related transducers range in capacity from ⅜ gallon to 75 gallons. Narda Ultrasonics Corp., Westbury, L. I., N. Y. Circle 156.

BARREL FINISHING COMPOUNDS for deburring, burnishing and descaling metals in barrel operations are the subjects of this booklet which also points up the necessity of using the right combination of media, solution, speed, and loading. Oakite Products, Inc., New York City. Circle 202.

BRAZING TUBE FITTING for permanent tubing joints in certain high-pressure service and other critical high-reliability applications gives joint strengths up to 130,000 psi in tensile strength and 48,000 psi in shear. Fittings are made in all commonly used body shapes for tubing of ¼ through 2 inches outside diameter. Parker Fittings & Hose Division, Parker-Hannifin Corporation, Cleveland, Ohio. Circle 158.

WIRE MARKERS made of all-temperature vinyl-cloth, flameproof aluminum foil, oil resistant all-vinyl, superthin polyester film, oilproof epoxy resin, Heat acetate cloth and glass cloth are useful for production line and maintenance coding of wires and components. W. H. Brady Co., Milwaukee, Wis. Circle 160.

SPRING WASHERS for spring problems involving high loads in limited space are designed to give the best economy of space combined with the highest load (30 to 1,200 lbs) and greatest deflection possible at a given stress level. Associated Spring Corp., Bristol, Conn. Circle 161.

STAINLESS STEEL THERMOMETER brochure lists complete specifications and price on the more than 100 Dillon angle form, straight form and special-purpose thermometers. Direct-drive bi-metal coils on each model eliminate gears and linkage. W. C. Dillon & Co., Inc., Van Nuys, California Circle 165.

MERCURY SWITCHES capable of carrying a steady flow of up to 70 amperes at 230 volts have glass bodies which are primarily hand-blown from special hard glasses, many from Jena sources. For this heavy-duty use the switches feature true mercury-to-mercury contact, with a ceramic shield fused into the body for protection against make-break spark damage. American Designed Components, Inc., Jericho, L. I., N. Y. Circle 168.

AIRCRAFT AND MISSILE ACCESSORIES brochure describes Barber-Colman's line of air valves and actuators, temperature control and positioning systems, transducers and thermostats. In addition, the reader is given a capsule view of the firm's development, testing and production facilities. Barber-Colman Company, Rockford, Illinois. Circle 162.

"ARMOROX" THERMOCOUPLES recently announced by Bristol are described and specified in a new bulletin. Available types, materials, sizes and thermocouple curves are detailed and appropriate applications are suggested. The Bristol Company, Waterbury, Conn. Circle 164.

"TAPERPLUG" TERMINAL for use with "MINEON" indicator light assembly can replace the AMP "53" series taper pin terminal where the latter is not practical—in smaller volume applications, for example. Drake Manufacturing Co., Chicago, Ill., Circle 167.

SAUCER FAN features an electrical driving motor built into the propeller hub which reduces the axial length of the fan to little more than the thickness of the propeller. Air delivery for the fan is 260 CFM against 0 static pressure. Rotron Manufacturing Co., Woodstock, N. Y. Circle 169.

ACTUATOR PACKAGES controlled by solenoids feature extremely low leakage—even with helium. Units are available for pressure ranges to 3,000 psi, for continuous duty temperatures to +500F, and are being used in the missile field for many hydraulic and pneumatic applications. Waldorf Fluid Systems Division, Waldorf Instrument Co., Huntington Station, N. Y. Circle 170.

CALCERITE casting compound, attractively priced, offers model makers, tooling establishments and hobbyists a simple, easy-to-work-with casting plastic which sets rapidly and cures to a hard, strong material. Furane Plastics Inc., L. A., Cal. Circle 172.

MOTOR GENERATORS have high frequency, high power ratings: 175 to 300 KW at 1000 cycles, 15 to 300 KW at 3000 cycles, 20 to 100 KW at 4200 cycles and 15 to 250 KW at 10,000 cycles. The vertical, water-cooled, inductor-type units are applicable for induction heating and melting. Electrical Division, Safety Industries, Inc., New Haven, Conn. Circle 173.

DATA PRESERVERS protect tape from detrimental effects of disturbing magnetic fields from transformers, motors, current carrying conductors, magnetrons, etc. Enclosures are either round or rectangular and can accommodate single or multiple tape reels. Magnetic Shield Division, Perfection Mica Co., Chicago, Illinois. Circle 171.

"DESIGNING CASTINGS for chemical milling," a new design bulletin, describes the first breakthrough in chemical milling of cast parts. Techniques are discussed which improve, in many cases, the surface finish of cast parts through chemical milling. United States Chemical Milling Corporation, Manhattan Beach, California. Circle 174.

PRECISION POWER SUPPLIES offer ±0.1 percent regulation and power ranges up to 500 watts. They are supplied for d-c or a-c inputs up to 1600 cps at any voltage ±10 percent and outputs are dc at various voltages and adjustable ±10 percent. Electric Regulator Corporation, Norwalk, Conn. Circle 205.

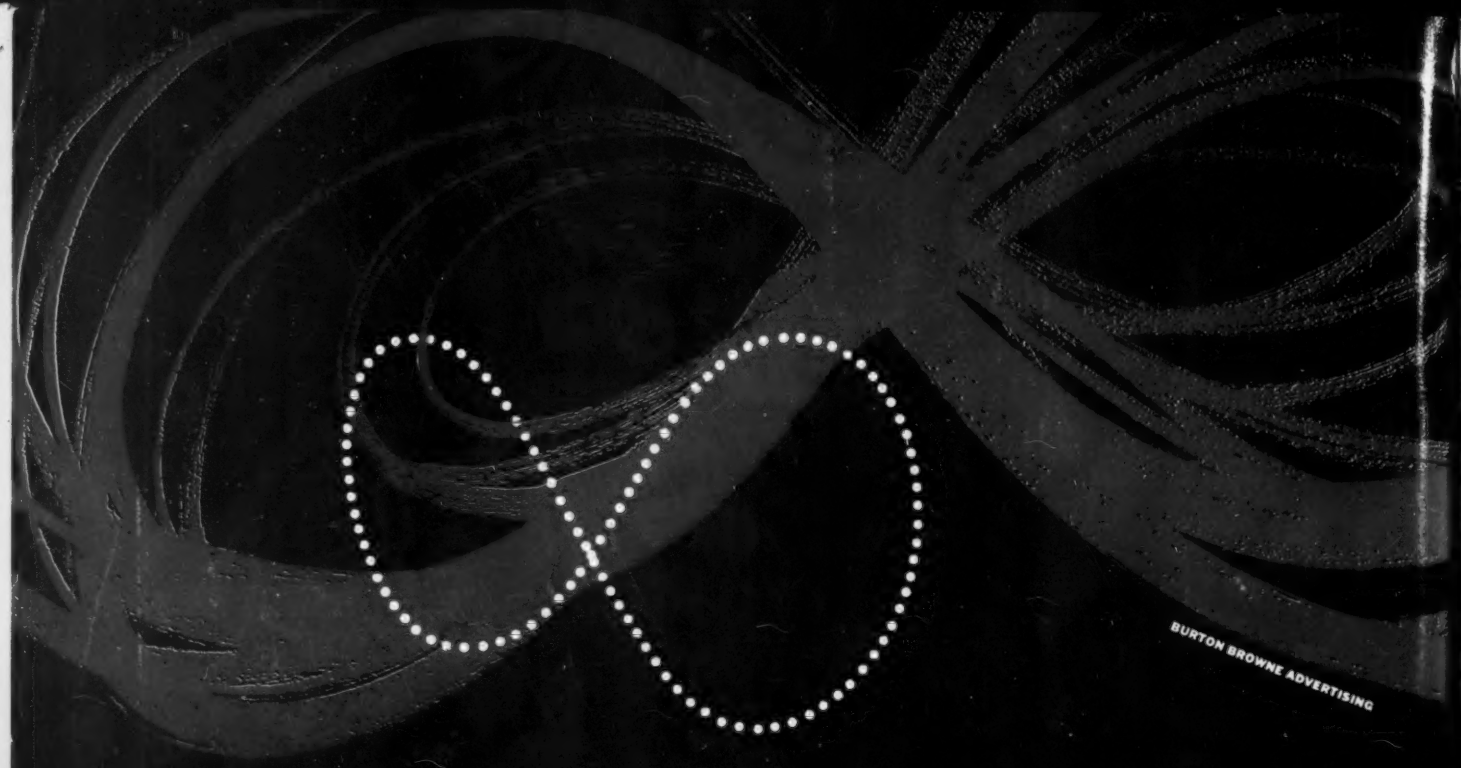
DC HIGH POTENTIAL TESTS to 30,000 V are possible with 15 d-c Hypot testers which cover output ranges of 5, 10, 20 and 30 KV DC. These models represent complete redesigns or new additions to the d-c Hypot line for design, production and maintenance testing of cables, motors, capacitors and insulation samples. Associated Research, Inc., Chicago, Illinois. Circle 176.

SINUSOIDAL OSCILLATOR is an epoxy encapsulated silicon transistor unit designed to create a sine wave signal source. Frequency range is 25 cps to 100 kcps and stability as a function of supply voltage and temperature has been emphasized. Solid State Electronics Co., Van Nuys, California. Circle 177.

POLARIZED RELAYS series P, for electronic and communications applications provide extremely fast action with freedom from bounce and handle 500 pulses per second and under some conditions over 1,000 pulses per second. The Hart Manufacturing Company, Hartford, Conn. Circle 178.

HARD SURFACING FACT FILE gives helpful data on Murex R line of 88 types and sizes of Hardex hard surfacing electrodes and rods. Complete data for reference files is listed on convenient 3″ x 5″ cards which provide finger tip access to this valuable information. Metal & Thermit Corp., Rahway, N. J. Circle 179.

FOR MORE INFORMATION ON BACK COVER:
CIRCLE NO. 34 ON INQUIRY CARD→



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